State of New York—Department of Agriculture

TWENTY-THIRD ANNUAL REPORT

OF THE

BOARD OF CONTROL

OF THE

NEW YORK

Agricultural Experiment Station

(GENEVA, ONTARIO COUNTY)

FOR THE YEAR 1904

With Reports of Director and Other Officers.

TRANSMITTED TO THE LEGISLATURE JANUARY 14, 1905

ALBANY
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1905

STATE OF NEW YORK.

No. 58.

IN ASSEMBLY,

January 14, 1905.

TWENTY-THIRD ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station

STATE OF NEW YORK:

Department of Agriculture,

Albany, *January* 14, 1905.

To the Assembly of the State of New York:

I have the honor to herewith submit the Twenty-third Annual Report of the Director and Board of Managers of the New York Agricultural Experiment Station at Geneva, N. Y., in pursuance of the provisions of the Agricultural Law.

I am, respectfully yours,

CHARLES A. WIETING,

Commissioner of Agriculture.

NEW YORK AGRICULTURAL EXPERIMENT STATION,

W. H. Jordan, *Director.*

Geneva, N. Y., *January* 14, 1905.

Hon. Charles A. Wieting, *Commissioner of Agriculture, Albany, N. Y.:*

Dear Sir.—I have the honor to transmit herewith the report of the Director of the New York Agricultural Experiment Station for the year 1904, in accordance with the provisions of chapter 439, Laws of 1904.

Yours respectfully,

S. H. HAMMOND,

President, Board of Control.

1904.

ORGANIZATION OF THE STATION.

BOARD OF CONTROL.

GOVERNOR BENJAMIN B. ODELL, JR., Albany.
STEPHEN H. HAMMOND, Geneva.
FREDERICK C. SCHRAUB, Lowville.
LYMAN P. HAVILAND, Camden.
EDGAR G. DUSENBURY, Portville.
JENS JENSEN, Binghamton.
THOMAS B. WILSON, Halls Corners.
MILO H. OLIN, Perry.
IRVING ROUSE, Rochester.
CHARLES W. WARD, Queens.

OFFICERS OF THE BOARD.

STEPHEN H. HAMMOND, *President.*

WILLIAM O'HANLON, *Secretary and Treasurer.*

EXECUTIVE COMMITTEE.

STEPHEN H. HAMMOND,
FREDERICK C. SCHRAUB,
LYMAN P. HAVILAND,
——— ———,
THOMAS B. WILSON.

STATION STAFF.

WHITMAN H. JORDAN, Sc. D., *Director.*

GEORGE W. CHURCHILL, *Agriculturist and Superintendent of Labor.*

WILLIAM P. WHEELER, *First Assistant (Animal Industry).*

FRED C. STEWART, M. S., *Botanist.*

HARRY J. EUSTACE, B. S., *Assistant Botanist.*

LUCIUS L. VAN SLYKE, Ph. D., *Chemist.*

EDWIN B. HART, B. S., *Associate Chemist.*

[1]WILLIAM H. ANDREWS, B. S.,
[2]CHRISTIAN G. JENTER, Ph. C.,
FREDERICK D. FULLER, B. S.,
[1]CHARLES W. MUDGE, B. S.,
ANDREW J. PATTEN, B. S.,
[1]FRANK A. URNER, A. B., *Assistant Chemists.*

HARRY A. HARDING, M. S., *Dairy Bacteriologist.*

MARTIN J. PRUCHA, Ph. B., *Assistant Bacteriologist.*

GEORGE A. SMITH, *Dairy Expert.*

FRANK H. HALL, B. S., *Editor and Librarian.*

PERCIVAL J. PARROTT, M. A., *Entomologist.*

[3]HAROLD E. HODGKISS, B. S., *Assistant Entomologist.*

SPENCER A. BEACH, M. S., *Horticulturist.*

[4]VINTON A. CLARK, B. S.,
[5]NATHANIEL O. BOOTH, B. Agr., *Assistant Horticulturists.*

ORRIN M. TAYLOR, *Foreman in Horticulture.*

[6]F. ATWOOD SIRRINE, M. S., *Special Agent.*

FRANK E. NEWTON,
JENNIE TERWILLIGER, *Clerks and Stenographers.*

ADIN H. HORTON, *Computer.*

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[1] Connected with Fertilizer Control. [2] Absent on leave. [3] Appointed August 15, 1904. [4] Resigned September 15, 1904. [5] Appointed October 10, 1904. [6] In Second Judicial Department.

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TWENTY-THIRD ANNUAL REPORT

OF THE

Board of Control of the New York Agricultural Experiment Station.

TREASURER'S REPORT.

GENEVA, N. Y., *October* 1, 1904.

To the Board of Control of the New York Agricultural Experiment Station:

As Treasurer of the Board of Control, I respectfully submit the following report for the fiscal year ending September 30, 1904.

GENERAL EXPENSE.

Receipts.

APPROPRIATION 1903—1904.

1903.			*Dr.*
Oct.	1.	To balance	$1,887 37
		To amount received from Comptroller	16,000 00
			$17,887 37

Expenditures.

	Cr.
By building and repairs	$3,003 92
By chemical supplies	224 13
By contingent expenses	1,952 93
By feeding stuffs	1,013 10
By fertilizers	57 20
By freight and express	553 42

1903.			*Cr.*
Oct.	1.	By furniture and fixtures	$542 54
		By heat, light and water	2,138 13
		By library	829 14
		By live stock	20 95
		By postage and stationery	1,077 34
		By publications	1,990 89
		By scientific apparatus	173 73
		By seeds, plants and sundry supplies	1,647 75
		By tools, implements and machinery	1,336 01
		By traveling expenses	1,299 36
1904.			
Oct.	1.	By balance	26 83
			$17,887 37

SALARIES.

Receipts.

APPROPRIATION 1903—1904.

1903.			*Dr.*
Oct.	1.	To balance	$5,997 91
		To amount received from Comptroller	22,000 00
			$27,997 91

Expenditures.

1904.			*Cr.*
		By salaries	$26,251 67
Oct.	1.	By balance	1,746 24
			$27,997 91

LABOR.

Receipts.

APPROPRIATION 1903—1904.

1903.			*Dr.*
Oct.	1.	To balance	$2,977 06
		To amount received from Comptroller	12,000 00
			$14,977 06

1904.		*Expenditures.*	*Cr.*
		By labor	$13,358 70
Oct.	1.	By balance	1,618 36
			$14,977 06

COMMERCIAL FERTILIZERS.

Receipts.

1903.		APPROPRIATION 1903—1904.	*Dr.*
Oct.	1.	To balance	$5,115 49
		To amount received from Comptroller	10,000 00
			$15,115 49

		Expenditures.	*Cr.*
		By chemical supplies	$285 37
		By contingent expenses	93 16
		By feeding stuffs	50
		By freight and express	105 76
		By furniture and fixtures	50 00
		By heat, light and water	935 29
		By postage and stationery	19 43
		By publications	1,887 48
		By salaries	5,762 74
		By scientific apparatus	66 58
		By seeds, plants and sundry supplies	3 64
		By traveling expenses	870 15
1904.			
Oct.	1.	By balance	5,035 39
			$15,115 49

CONCENTRATED FEEDING STUFF INSPECTION.

Receipts.

1903.		APPROPRIATION 1903—1904.	*Dr.*
Oct.	1.	To balance	$626 21
		To amount received from Comptroller	2,500 00
			$3,126 21

Expenditures.

			Cr.
		By chemical supplies	$236 68
		By freight and express	17 35
		By contingent expenses	60
		By postage and stationery	7 46
		By publications	762 44
		By salaries	1,320 31
		By scientific apparatus	63 53
		By seeds, plants and sundry supplies	22 44
		By traveling expenses	352 36
1904.			
Oct.	1.	By balance	343 04
			$3,126 21

SECOND JUDICIAL DEPARTMENT.

APPROPRIATION 1903—1904.

Receipts.

		Dr.
1903.		
	To amount received from Comptroller	$3,582 05

Expenditures.

	Cr.
By chemical supplies	$19 88
By contingent expenses	16 05
By fertilizers	58 72
By freight and express	1 15
By labor	129 10
By postage and stationery	62 20
By publications	2,015 92
By salaries	275 33
By scientific apparatus	411 33
By seeds, plants and sundry supplies	189 91
By traveling expenses	337 56
By rents	59 00
By reverted to State treasury	5 90
	$3,582 05

FERTILIZER LICENSE.

1903—1904.

Receipts.

	Dr.
To amount received for fertilizer licenses.	$11,870 00

Expenditures.

	Cr.
By amount remitted to the Treasurer, State of New York	$11,870 00

FEEDING STUFF LICENSE.

1903—1904.

Receipts.

	Dr.
To amount received for feeding stuff licenses	$4,075 00

Expenditures.

	Cr.
By amount remitted to the Treasurer, State of New York	4,075 00

FIRE PROTECTION.

APPROPRIATION 1903—1904.

Receipts.

	Dr.
To amount received from Comptroller...	$4,863 00

Expenditures.

	Cr.
By equipment	$1,344 00
By construction	3,465 00
By furniture and fixtures.............	54 00
	$4,863 00

REPAIR FUND.

APPROPRIATION 1903—1904.

Receipts.

	Dr.
To amount received from Comptroller....	$1,190 17

Expenditures.

		Cr.
	By repairs	$1,190 17

CARRIAGE HOUSE AND HORSE STABLE.

APPROPRIATION 1903—1904.

		Dr.
	To amount received from Comptroller	$3,000 00

Expenditures.

		Cr.
	By construction	$3,000 00

INSURANCE MONEY.

1903.		
Oct. 1.	To balance	$1,108 07

Expenditures.

	By building and repairs	$449 50
	By feeding stuffs	101 33
	By seeds, plants and sundry supplies	76 50
	By tools, implements and machinery	293 67
1904.		
Oct. 1.	By balance	187 07
		$1,108 07

All expenditures are supported by vouchers approved by the auditing committee of the Board of Control which have been forwarded to the Comptroller of the State of New York.

UNITED STATES APPROPRIATION, 1903—1904.

Receipts.

	Dr.
To receipts from the Treasurer of the United States as per appropriation for fiscal year ending June 30, 1904, as per Act of Congress approved March 2, 1887	$1,500 00

Expenditures.	*Cr.*
By salaries	$120 00
By building and repairs...............	23 03
By postage and stationery.............	46 14
By library	13 71
By heat, light, water and power........	212 52
By freight and express................	6 16
By seeds, plants and sundry supplies...	174 81
By fertilizers	213 66
By labor	3 30
By furniture and fixtures.............	15 00
By live stock	175 00
By contingent expenses	103 10
By traveling expenses	207 17
By tools, implements and machinery....	66 75
By scientific apparatus	119 65
	$1,500 00

WILLIAM O'HANLON,
Treasurer.

DIRECTOR'S REPORT FOR 1904*

Honorable Board of Control of the New York Agricultural Experiment Station:

GENTLEMEN.—In accordance with the usual custom, I have the honor to submit herewith the annual report of the New York Agricultural Experiment Station for the year 1904. In the character and progress of the Station work the report is not unlike that of previous years. Certain efforts to which the members of the Staff have given their time and energy have been productive of definite and unquestionably beneficial results, while in other directions the only report that can be made is that the problems which it is sought to solve are still being pursued. This is the usual course of scientific investigation.

It is sometimes discouraging, and to the public is often disappointing, that so few of the unsolved problems that present themselves to the agricultural practitioner can at any one time be made the subject of investigation and that progress toward placing agricultural knowledge upon a surer and safe basis through scientific effort is necessarily slow.

CHANGES IN THE STATION STAFF.

Fortunately for the Station fewer changes have occurred in the Station staff than has been the case during some previous years. Mr. Vinton A. Clark, First Assistant Horticulturist, after two years of faithful and efficient service, resigned his position to accept a more prominent one in connection with the Agricultural Experiment Station of the University of Arizona. This vacancy has been filled by the appointment of Mr. Nathaniel O. Booth, who occupied the position previous to the appointment of Mr. Clark.

Mr. Harold E. Hodgkiss, B. S., graduate of the Massachusetts Agricultural College, has been appointed to the position of Assistant Entomologist.

*A reprint of Bulletin No. 260.

CHANGES IN THE LAWS RELATING TO THE STATION

The Legislature of 1904 enacted considerable legislation which materially affects the status of this institution. The law under which the Station is organized and carries on its work was modified in several particulars, the principal changes being the placing of the Commissioner of Agriculture on the Board of Control, the establishing of closer relations between the Department of Agriculture and the Experiment Station and the removal of any indefiniteness as to the responsibilities of the Board. The relation of the Station to certain inspection laws was very materially changed. Heretofore the administrative laws controlling the sale and inspection of fertilizers and concentrated feeding stuffs have been in the hands of the Director of the Station, subject to the regulations of the Board of Control. Under the terms of the new laws their administration rests with the Commissioner of Agriculture, it still being the duty of the Station to analyze the samples of fertilizers and feeding stuffs which may be selected under the authority of the Commissioner of Agriculture. It is not undertood, at least it was not so expressed, that this readjustment of responsibility for the execution of the provisions of the inspection laws was due to any dissatisfaction with the administration of the laws by the Station authorities, but it was felt, rather, that the enforcement of all agricultural laws should be unified under the control of a single department. Doubtless these changes will be found to have been wisely conceived. The other important item of legislation which should be mentioned in this connection was the passage of an act giving the Director of this institution broad and unquestionable authority to publish "results of analyses made by him, or under his authority or direction, of any commodities or substances analyzed in pursuance of or under the provisions of the statutes of this State." Authority was also granted to "publish bulletins containing results of analyses made of such substances or commodities, which analyses were made prior to the passage of this act and which have not heretofore been published." Such authority wisely used is often essential to the protection of the best interests of the agricultural public.

APPROPRIATION FOR A NEW BUILDING.

With insurance money received by the Station and with an appropriation made by the Legislature of 1903, the losses occasioned by the fire in 1902 have been replaced, with the exception of a building for the storage of farm machinery and grain. Through an appropriation of $4,500, made by the Legislature of 1904, this building is now in process of construction, and when this is completed the Station will be better equipped with buildings of all kinds than ever before in its history.

GENERAL IMPROVEMENTS.

For some time subsequent to the fire of 1902, the grounds of the Station presented a somewhat unattractive appearance, due in part to the unsightly foundations of the burned buildings and the clutter attendant upon building operations. Such conditions no longer exist. The new buildings are in place, old buildings are removed, a large amount of necessary grading has been done, all the buildings have been newly painted in more desirable colors and the appearance of the whole institution is now so attractive that it is easy to regard the fire as a fortunate occurrence.

HOUSES FOR THE STATION STAFF.

The building equipment of the Station now provides for the housing of five families belonging to the Station staff. Under the conditions at present prevailing the homes of the staff are widely scattered. The married members, other than those provided for on the Station grounds, live in various parts of the city in rented houses. There is involved in this arrangement a great deal of uncertainty as to permanence and desirability of location. It is also often inconvenient and it certainly makes exceedingly difficult and impossible, almost, that social unity which should prevail at such an institution and which is a large factor in its spirit and success. The desirability and attractiveness of any salaried position are to a very large degree determined by social relations and by the environment and influences which surround the home. In view of the fact that there is an almost continuous effort to draw away from the Station its best men, sometimes successfully, it would seem to be a good policy to do all that is possible to render positions at the Experiment Station so attractive that efficient and useful men shall not be drawn away. It is fair to raise the question, therefore, whether, if it is not inconsistent with the established policy of the State, several more houses should not be erected on the Station grounds, sufficient in number at least to accommodate the heads of departments and certain minor officials whose presence near the Station at all times is very essential.

MAINTENANCE FUND.

The various funds that were appropriated by the Legislature of 1904 for the maintenance of the Station during the fiscal year beginning October 1, 1904, were as follows:

Salaries	$22,000
Labor	13,000
Expenses of various departments of research	16,000
General expense, heat, light, water, apparatus, repairs, etc.	4,000
Expenses of horticultural investigation	8,000
Fertilizer inspection	10,000
Feeding stuff inspection	3,500

By action of your Board, the Legislature is asked to appropriate similar sums for the fiscal year beginning October 1, 1905, with the exception that the amount for salaries is recommended to be $23,000, and the amount for the expenses of the various departments only $15,000, the total sum asked for remaining unchanged.

THE MAILING LIST.

During the past year the mailing list has been revised by removing all names of those deceased and those who have changed their place of residence without notice to the Station, so that they were not receiving the bulletins. Although the addition of new names to the list has been no less than during former years, there has been an apparent decrease in the number of persons to whom our publications have been sent in New York.

The number of names now on our records is as follows:

BULLETIN LISTS, JANUARY 1, 1905.

Popular Bulletins.

Residents of New York	33,641
Residents of others states	2,122
Newspapers	772

Experiment stations and their staffs	917
Miscellaneous	131
Total	37,583

Complete Bulletins.

Experiment stations and their staffs	917
Libraries, scientists, etc	169
Foreign list	230
Individuals	2,771
Miscellaneous	131
Total	4,218

AN IMPORTANT STATION PUBLICATION.

There is now in press a publication for which the Legislature of 1904 generously provided, which is to be known as the "Apples of New York." This publication is to be issued in two parts. The first, or the one now in press, will include the late varieties of apples, and the second part will be devoted to the summer and fall varieties. It is expected that the two parts will present about 500 pages of printed matter and approximately 300 plates, nearly half of which will be representations in color of the most important varieties. This work will present the results of apple studies which have been carried on at the Station for over 20 years, besides much data collected from practical orchardists throughout the State. As the number of copies authorized is limited, every effort should be made to place them in the hands of those who are directly interested in apple culture either as orchardists or nursery men.

DEMONSTRATION EXPERIMENTS.

There is a growing tendency in experiment station work towards carrying on demonstration experiments in connection with the commercial operations of the farm and orchard. It is very evident that no experiment station farm can be so organized as to give opportunities for observations in connection with all classes of commercial work. For this reason, it is necessary for a station to make arrangements with farmers and orchardists to obtain control of certain areas on particular farms where a good opportunity is offered to conduct desired experiments. These experiments are not in the nature of object lessons for the imparting of information already known to be of practical utility, but are intended to determine whether certain new knowledge or methods may be efficiently applied to practice. The New York Experiment Station is not behind other institutions in utilizing this means of prosecuting its work. During the past year the Station has either conducted work or arranged for work in numerous localities in the State. These experiments may be classified as follows:

TREATMENT OF ASPARAGUS RUST.

F. A. Sirrine....................................Riverhead.

TREATMENT OF RASPBERRY CANE BLIGHT.

Dobson Bros ....Charlotte.

POTATO SPRAYING EXPERIMENTS.

1 Brainerd and Beaumont......................Gainesville.
2 Robert Dunn............................West Henrietta.
3 F. E. Gott.................................Spencerport.
4 P. H. Pettit...........................Clifton Springs.
5 H. E. Cook....................................Denmark.
6 W. E. Griffith.................................Madrid.
7 N. W. Porter...................................Malone.
8 Datus Clark ....Peru.
9 John Middleton ....Sliters.
10 R. C. Colyer................................Woodbury.
11 R. E. Colver ....Farmingdale.
12 W. H. Satterly..............................Mattituck.
13 H. A. Jagger..............................Southampton.
14 L. E. Downs...............................Southampton.
15 F. A Sirrine................................Riverhead.

EXPERIMENTS WITH GRAPE STOCKS.

Irving A. Wilcox..............................Portland.
T. H. King................................Trumansburg.

THE ECONOMY OF DWARF ORCHARDS.

A. Wood and Son.......................... Carlton Station.
F. E. Dawley.............................. Fayetteville.
Edward Van Alstyne........................ Kinderhook.

SYSTEMS OF ORCHARD MANAGEMENT.

W. D. Auchter............................. South Greece.
Grant G. Hitchings........................ South Onondaga.

GROWTH OF FOREIGN VARIETIES OF CHESTNUTS.

W. D. Barns and Son....................... Middlehope.

EXPERIMENTS WITH FORAGE CROPS.

F. A. Sirrine............................. Riverhead.
W. A. Fleet............................... Cutchogue.
Edward Van Alstyne........................ Kinderhook.

A TEST OF SULPHUR WASHES.

E. E. Robinson............................ Centreville.
F. A. Sirrine............................. Riverhead.
C. W. Ward................................ Queens.
White and Rice............................ Yorktown.
Frank Stevens............................. Geneva.
C. K. Scoon............................... Geneva.
John Maney................................ Geneva.
T. C. Maxwell and Bros.................... Geneva.
H. H. Loomis.............................. Geneva.
Rice Bros................................. Geneva.
Geo. Callard.............................. Carlton Station.
F. G. Whitney............................. Youngstown.
W. H. Woolworth........................... Youngstown.
A. H. Dutton.............................. Youngstown.
Will Hall................................. Youngstown.

CONTROL OF CODLING MOTH.

White and Rice............................ Yorktown.
Frank Stevens............................. Youngstown.
T. C. Maxwell and Bros.................... Geneva.

The Station officials desire to acknowledge their obligations to those persons with whom they are coöperating and to express appreciation of the faithful and efficient service that is being rendered.

DEPARTMENT OF ANIMAL HUSBANDRY.

Results from poultry feeding experiments.—In earlier poultry feeding experiments at this Station the desirability of sometimes using animal food with the standard grains has been plainly shown. For growing ducklings this was especially evident.

Knowing the general character of the food for wild birds it is to be expected that the young of domestic fowls might subsist to advantage largely upon fresh animal food; but the animal foods of commerce have been subjected to various processes for their separation or preservation and are most convenient for use in the dried form.

Very few data existed concerning the amount or proportion of commercial animal food that could be efficiently or profitably used. To partly supply this lack, feeding experiments have been made, results from some of which are reported in a recent bulletin.

Rations in which these foods supplied 94 per ct. of the total dry matter and 98 per ct. of the protein were fed to ducklings without any apparent ill effects.

During the first few weeks growth was more rapid, and equal growth made from less food (even at a lower cost for food) under a ration in which 60 per ct. of the protein was obtained from animal food than under rations having respectively 20, 40 and 80 per ct. of the protein derived from this source.

Later growth was made at somewhat more economical expenditure of food under the "20 per ct. ration," but was slower. Under the rations containing larger proportions of animal food, marketable size was reached about two weeks sooner.

Results on the whole favored the use, for the first few weeks, of the ration in which 60 per ct. of the protein came from animal food, and later those containing larger and increasing proportions of grain foods.

DEPARTMENT OF BACTERIOLOGY.

Fermentation in canned peas.—The canning industry in this State utilizes over $3,500,000 worth of farm products annually.

The losses from fermentation of the finished products are often large and the causes of the same are obscure. The results of a study of fermentation in canned peas have been reported. The trouble was caused by a species of bacterium which produced unusually resistant spores. Heating the canned peas to 240° F. for 30 minutes was found to be sufficient to prevent the fermentation. This conclusion was tested by canning a ton of peas to which cultures of the bacillus causing the trouble had been added. A large factory which had previously suffered heavy losses put our suggestions into practice with entire success.

Black rot of cabbage spread by cabbage seed.—A study of black rot of cabbage has been carried on for a number of years in connection with the Botanical Department. The agencies by which the disease spreads are being investigated. Black rot is found in the seed-bearing plants and the germ causing the disease is present on the seed from such plants. It has also been found that the disease germs are able to remain alive on the seed at least eleven months. This shows that at the time of planting the seed may carry the disease germs. We have here an explanation for severe outbreaks where the disease had been previously unknown and there was no apparent source of infection.

Soaking the seed for fifteen minutes in a 1:1000 corrosive sublimate solution or in a 0.4 per ct. formalin solution just before planting is suggested as a cheap and effective means of destroying the germs upon the seed.

DEPARTMENT OF CHEMISTRY.

Chemical changes in the souring of milk and their relations to cottage cheese.—This work was undertaken for the purpose of learning some facts about the chemical changes that occur in milk when it sours, and also for the purpose of applying the facts to the manufacture of cottage (Dutch) cheese. In addition, a study was made (1) of the chemical changes that take place in cottage cheese after it is prepared and (2) of the digestibility of fresh cottage cheese as compared with new cheddar cheese. The action of lactic acid, formed in milk by the fermentation of milk-sugar, upon the milk-casein was found to take place in two stages; in the first stage the acid forms a compound which in Bulletin 215 was called casein monolactate, but which by more recent work we have found to be free casein; in the second stage, after the formation of more acid, the casein unites with this acid to form a compound which is the familiar solid substance of sour milk and which constitutes a large part of the dry matter of cottage cheese. The conditions of temperature were ascertained for the best yield and quality of cottage cheese. Success was attained in making good cottage cheese from milk by direct addition of hydrochloric acid, thus shortening the time of manufacture from one or two days to as many hours. It was found that very slight chemical change occurs in cottage cheese after it is made, and in this respect the behavior of cottage cheese is wholly unlike that of cheddar cheese. According to popular belief, cottage cheese is more readily digested than cheddar cheese, and this belief was supported by artificial digestions of the two kinds.

The composition of commercial whale-oil soaps in relation to spraying.—Many complaints have been received from fruit-growers in regard to the unsatisfactory results given by commercial whale-oil soaps in spraying fruit trees. In some cases the insects were not killed, while in other cases the foliage was seriously injured. In response to inquiries on this subject, an investigation was undertaken to study the composition of the commercial whale-oil soaps commonly found in the market. It was found that these soaps vary greatly in composition. Different lots of soap from the same factory were found to contain actual soap varying from 24 to 46 per ct. So great is the variation in composition of these soaps that they cannot be relied upon at all for giving uniform results. Since manufacturers are unwilling to furnish commercial whale-oil soap of guaranteed composition, experiments were made resulting in the recommendation of a certain formula for home-manufacture of fish-oil soap. The home-made soap destroys plant lice and does not injure foliage; it costs less and can be relied upon to give uniform results. In addition, a study was made of the amount of free-alkali in soap that will do injury to foliage. Soaps containing less than five per cent. of free alkali did no injury under the conditions employed. Full details are given for the home-making of fish-oil soap, and addresses are given of parties who will furnish materials.

The science and practice of making cider-vinegar.—In response to numerous inquiries made by farmers as to why their home-made cider-vinegar was so often below the legal standard, an investigation was begun seven years ago having for its object a thorough study of the vinegar-making process, starting with material known to be normal. Some 36 experiments were made in the investigation. The composition of apple juice is given for a large number of different varieties of apples. The chemical changes of apple juice under different conditions during the alcoholic and acetic stages of fermentation were studied and a practical application made to the relations and control of those fermentations in making cider-vinegar. Attention is called to the fact that good vinegar may loose its acidity on standing. The causes and remedies are given. Other topics treated in this work are the behavior of malic acid during fermentations, the solids of apple juice and cider-vinegar, cider-vinegar in relation to legal standards, conditions commonly producing cider-vinegar of poor quality, and directions for home-manufacture of cider-vinegar.

Study of the principal phosphorus compound of wheat bran.—As a necessary part of an extended investigation of the metabolism and function of phosphorus compounds in the nutrition of the milch cow, a study was made of the principal phosphorus compound of wheat bran. It was found to be undoubtedly a previously known non-nitrogenous body with the formula $C_2 H_8 P_2 O_9$ or anhydro-oxmethelene-diphosphoric acid. Since this body was identified investigations have been conducted which indicate that it may occupy a peculiar place in the nutrition of the cow. Further observations are planned with reference to the elucidation of this point.

DEPARTMENT OF ENTOMOLOGY.

The lime-sulphur-soda wash for orchard treatment.—The investigations to determine the value of this spray for orchard treatment have been continued. Applications of the wash for the control of the scale gave somewhat variable results which indicate that the various preparations were not always equally destructive to the scale. Some treatments proved very effective, showing that an efficient spray may be prepared without the use of external heat. As there is a demand for such a wash upon the part of smaller orchardists further experiments are to be undertaken to devise methods by which all preparations may be made equally effective.

In the experiments with apple trees applications of the wash proved very efficient in preventing injuries by early spring leaf-eating insects as the bud moth and case bearer. Such treatment was of little or no value for the codling moth. Owing to the absence of apple scab the value of a sulphur wash for this disease remains undetermined. For the treatment of peaches it has been shown that one application of a sulphur wash during dormant season will efficiently control both leaf curl and scale. Future experiments are necessary to determine the value of the sulphur washes as combined fungicides and insecticides for the treatment of other varieties of fruit.

Fall use of sulphur sprays.—In this work a study has been made of the effects of fall applications of sulphur washes upon fruit and leaf buds, and upon the scale. The experiments were conducted in three orchards, two near Geneva and one near Queens, L. I. One of these was a thrifty young orchard of peaches and plums which had received the best of attention in every respect and contained no scale. The other orchard at Geneva, of apples, pears, crab apples, cherries and plums, was older, was well infested with scale, and had received no treatment for insects or diseases, but had been well cared for in other respects. The third orchard, at Queens, contained only apples and peaches, and showed plainly the effects of scale injury. The sprayed trees in the three orchards numbered 66 large apple trees, 33 pear trees, 257 plum trees, 39 cherry trees, 6 crab apple trees and 252 peach trees. Applications of the washes were made during November. In the orchard which was free of scale the applications caused a diminution in the amount of bloom and foliage of peaches and plums which varied according to the spray applied, the lime-sulphur proving the least destructive. In orchard II, which was infested with scale, the plums lost from 10 to 50 per ct. of their blossoms and had slight injuries to the leaf buds upon the lower branches. Morello cherries suffered a loss of five per ct. of the blossoms. Apples and pears were affected in the same degree. Crab apples bore a full crop of fruit and foliage. In orchard III, which was infested with scale, there was no apparent reduction in the blossoms and leaves upon the moderately infested trees.

The lime-sulphur wash, the lime-sulphur-salt wash and the lime-sulphur-caustic soda wash were equally effective as insecticides. Applications of these sprays controlled the scale and with some slight exceptions insured the production of clean fruit.

DEPARTMENT OF HORTICULTURE.

Apples in storage.—In Bulletin 248 different varieties of apples are treated with regard to their season of ripening and keeping and their adaptability for storage purposes. The bulletin is based upon material obtained from three distinctly different sources: First, from storage tests made at this Station with fruit grown in the Station orchards; second, from men of practical experience in handling fruit both in cold storage and in ordinary fruit warehouses; third, from tests made by the U. S. Department of Agriculture in cooperation with this Station with numerous varieties of apples from the Station orchards stored in chemical cold storage. The tests which were made at this Station were undertaken with the primary purpose of determining the ordinary season of ripening and the keeping qualities of the different varieties which were under test in the Station orchards. This work brought out some results of general interest concerning the keeping of apples, worthy of publication, but which, when regarded from the standpoint of the general adaptability of the varieties to cold storage purposes, were incomplete. In order that a more complete account of the behavior of different varieties in storage might be presented than could be derived from the experiments at the Station, men of practical experience in storing apples on a large scale under commercial conditions were consulted and much material of practical importance was thus obtained:

In 1901-2 this Station furnished over 100 varieties of apples to be used in cold storage tests at Buffalo under the direction of Profs. G. Harold Powell and S. H. Fulton of the U. S. Department of Agriculture. The results of their work were first reported in Bulletin 48 of the Bureau of Plant Industry, U. S. Department of Agriculture. Much material which was thus made available has been included in the notes that are published in Bulletin 248. In this bulletin varieties which are included in the Station tests are arranged chronologically according to the average life of the fruit in storage. The experience of fruit storage men is then given concerning conditions which affect the keeping qualities of apples, the comparative efficiency of different kinds of storage as applied to different varieties, the temperature at which different varieties should be held in cold storage, the relation between seasonal differences and keeping qualities of apples, the kinds of deterioration that may precede decay in cold storage and the varieties which are liable to each.

The varieties are then treated in alphabetical order, giving for each the results of the tests which were made in the natural temperature storage rooms at this Station, the results of the tests made in cold storage by the U. S. Department of Agriculture, and lastly a summary of the experience of cold storage men with the variety.

Selecting seed by specific gravity.—The method of seed selection by means of salt solutions has long been known to gardening. A simpler form of the method, which consists in floating off light seed in pure water, is practiced by some in this country, particularly by growers of lettuce under glass. But the method appears never to have come into any considerable vogue either in Europe or America despite the fact that striking results have repeatedly been obtained by its use and that it has been recommended by several European experimenters. In Bulletin 256 a variation of the method of seed selection by salt solutions is described, in which separates are made at much shorter intervals than in the method as heretofore practiced. This permits of determining with greater precision the distribution of seeds with regard to specific gravity. It is found that within the limits of the variety the lower the specific gravity the greater the proportion of small seeds, and vice versa. The separation of seeds by the method of salt solutions is, therefore, in part a crude separation according to size.

A quite definite correlation exists between the specific gravity of a seed and its germination. Seeds of low specific gravity do not germinate at all. Those in a range higher germinate scantily and in many cases produce comparatively weak plants. Seeds of highest specific gravity, or, in case of oil bearing seeds, those of intermediate specific gravity, give the highest percentage of germination. To some extent a correlation appears to exist also between the specific gravity of the seed and the vigor of the resulting plant.

Differences in specific gravity are due either to differences in structure or differences in composition. If the differences in composition are not obscured by differences in structure, which they often are, the differing specific gravities to which they give rise are indexes to the quality of the seed. The report in Bulletin 256 is based on only one season's work. The literature on the subject is reviewed and preliminary observations are presented. The subject is worthy of further investigation.

Shading strawberries.—In order to study the practical value of the method of shading strawberries, experiments were carried on in 1902 and 1903 in three different localities in this State, the results of which are given in Bulletin 246. The materials used for shading were two grades of thin cheese cloth stretched about twenty inches above the plants. The cost of shading was at the rate of about $350 per acre.

Records are given showing the temperature of the air and of the soil underneath the cloth and outside, cloudiness, evaporation, yields of fruit, etc. The temperature of the air and of the soil underneath the cloth was usually slightly higher than outside. There was also more moisture in the air and in the soil underneath the cloth than outside, the covering diminishing the evaporation about one-half. Shading proved to be somewhat beneficial to the blossoms as a protection against frost. The shaded plants made more rapid growth of foliage and seemed more vigorous and thrifty, but shading appeared to slightly increase the susceptibility of the plants to leaf blight and mildew. Pollination appeared to be as complete underneath the covering as outside.

In regard to yield, there was a considerable increase with the thinner grade of cloth, but a marked decrease with the heavier grade. Shading in some cases produced a considerably larger berry, more attractive in color, but somewhat softer, slightly less acid than those grown outside, also containing a smaller percentage of sugar.

In no case was the increase in yield sufficient to compensate for the cost of the shading. It is believed that under certain conditions the practice of shading may be adapted for the growing of fancy fruit and is likely to be most useful in localities having a large amount of sunshine, a light rainfall and considerable wind.

INSPECTION WORK.

Inspection of fertilizers for 1904.—In May of this current year, an amendment to the fertilizer law of this State was made by the Legislature, as a result of which the administration of the law was transferred to the Department of Agriculture. This Station continues to perform the chemical analyses. The analyses published in Bulletin 253 represent only samples of fertilizers collected by this Station previous to the time the law was amended in May.

During the spring of 1904, the Station's collecting agents visited 98 towns between March 26 and May 9, obtaining 468 samples of commercial fertilizers. These samples represent 371 different brands, the product of 49 different manufacturers, each manufacturer being represented by from one to 145 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid and potash without nitrogen.	Brands of complete fertilizers.
7	22	4	16	47	275

The following tabulated statement shows the average composition of the complete fertilizers collected, together with a comparison of the guaranteed composition and that found by analysis:

	PER CT. GUARANTEED.			PER CT. FOUND.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average	Lowest.	Highest.	Average.	
Nitrogen	0.50	9.88	2.01	0.54	9.74	2.12	0.11
Available phosphoric acid	1.50	10.00	7.56	1.26	11.38	8.52	0.96
Insoluble phosphoric acid	......	......	......	0.04	6.52	1.80	....
Potash	0.50	10.00	4.50	0.16	10.74	4.77	0.27
Water-soluble nitrogen	......	......	......	0.00	9.62	1.01	....
Water-soluble phosphoric acid	......	......	......	0.04	8.96	5.98	....

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial Valuation of Complete Fertilizer.	Selling Price of One ton of Complete Fertilizers.			Average increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$19 85	$17 00	$45 00	$27 56	$7 71

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	24.30 cents.
Phosphoric acid (available)	5.90 cents.
Potash	6.25 cents.

Feeding stuff inspection for 1904.—Previous to May 3, 1904, one hundred and four manufacturers or jobbers registered the required guarantees and paid the license fee on one hundred and fifty-four brands of feeding stuffs to be placed on sale in New York State in 1904.

The list of licensed brands are classified as follows:

Proprietary or mixed feeds	70 brands.
Meat and bone meal	16 brands.
Hominy feed or chop	13 brands.
Gluten feeds	12 brands.
Linseed oil meals	11 brands.
Distillers' grains	9 brands.
Cottonseed meals	6 brands.
Malt sprouts	5 brands.
Corn brans	3 brands.
Molasses feeds	3 brands.
Gluten meals	2 brands.
Sugar beet refuse	2 brands.
Cottonseed feed	1 brand.
Germ oil meal	1 brand.
Total	154 brands.

The number of samples collected and analyzed up to May 3d was 263, representing 203 brands.

CLASSIFICATION OF SAMPLES ANALYZED.

NAME OF FEED.	Number samples.	Number brands.
Cottonseed oil meal	17	13
Linseed oil meal	19	10
Linseed cake, ground	3	3
Distillers' grains	12	8
Brewers' grains	2	1
Malt sprouts	7	6
Gluten meal	1	1
Gluten feed	10	7
Germ oil meal	1	1
Germaline	2	1
Hominy feed or chop	14	10
Mixed feeds (bran and middlings)	35	30
Oats and their by-products	6	5
Compounded feeds, proprietary and otherwise	96	74
Poultry foods	34	29
Miscellaneous feeds	4	4
Total	263	203

A study of the figures showing the results of the inspection up to May 3 reveals the fact that the samples representing quite a large number of brands contained considerably less protein than called for by guarantees. In all, at least, fifty-two samples showed a larger deficit than would be regarded as reasonable.

The deficit occurred as follows:

Cottonseed meal	5 samples.
Linseed meal	9 samples.
Distiller's dried grains	4 samples.
Gluten feed	4 samples.
Hominy feed	6 samples.
Compounded and proprietary feeds	18 samples.
Poultry foods	6 samples.
	52

One brand, licensed as cottonseed meal, sold by the Husted Milling and Elevator Co., of Buffalo, N. Y., and recorded as manufactured by R. W. Biggs & Co., of Memphis, Tenn., was found to contain only 21.8 per ct. of protein whereas the minimum guarantee was 41 per cent.

The material was evidently cottonseed feed, or cottonseed meal mixed with ground hulls. Such a feed is fraudulent in its character.

BULLETINS PUBLISHED IN 1904.

No. 245. February.—Chemical changes in the souring of milk and their relations to cottage cheese. L. L. Van Slyke and E. B. Hart. Pages 36.

No. 246. February.—An experiment in shading strawberries. O. M. Taylor and V. A. Clark. Pages 22, plates 2.

No. 247. February.—The lime-sulphur-soda wash for orchard treatment. P. J. Parrott, S. A. Beach and H. O. Woodworth. Pages 21, plates 4.

No. 248. March.—New York apples in storage. S. A. Beach and V. A. Clark. Pages 70, plates 2.

No. 249. March.—A swelling of canned peas accompanied by a malodorous decomposition. H. A. Harding and J. F. Nicholson. Pages 16.

No. 250. March.—The nature of the principal phosphorus compound in wheat bran. A. J. Patten and E. B. Hart. Pages 8.

No. 251. October.—Vitality of the cabbage black rot germ on cabbage seed. H. A. Harding, F. C. Stewart and M. J. Prucha. Pages 18, plate 1.

No. 252. May.—Report of analyses of commercial fertilizers for the spring and fall of 1903. W. H. Jordan, L. L. Van Slyke and W. H. Andrews. Pages 78.

No. 253. August.—Report of analyses of commercial fertilizers for the spring of 1904. W. H. Jordan, L. L. Van Slyke and W. H. Andrews. Pages 49.

No. 254. August.—Fall spraying with sulphur washes. P. J. Parrott and F. A. Sirrine. Pages 21, plates 6.

No. 255. September.—Inspection of feeding stuffs. W. H. Jordan and F. D. Fuller. Pages 28.

No. 256. October.—Seed selection according to specific gravity. V. A. Clark. Pages 59, plates 2.

No. 257. November.—The composition of commercial soaps in relation to spraying. L. L. Van Slyke and F. A. Urner. Pages 12.

No. 258. December.—A study of the chemistry of home-made cider-vinegar. L. L. Van Slyke. Pages 55.

No. 259. December.—The proportion of animal food in the ration for ducklings. W. P. Wheeler. Pages 16.

No. 260. December.—Director's report for 1904. Pages 18.

W. H. JORDAN,
Director.

New York Agricultural Experiment Station,
Geneva, N. Y., Dec. 15, 1904.

REPORT

OF THE

Department of Animal Husbandry

W. H. Jordan, *Director*.

W. P. Wheeler, *First Assistant*.

Table of Contents.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

THE PROPORTION OF ANIMAL FOOD IN THE RATION FOR DUCKLINGS.*

W. P. Wheeler.

SUMMARY.

For growing ducklings rations which contained animal food have proved generally much superior to others of vegetable origin which had, according to the limited methods of estimation commonly used, equal nutritive value.

Results here reported were obtained in experiments made to learn how much animal food, in the prepared forms commonly found in the market, could be safely and effectively fed.

Rations in which these foods supplied 94 per ct. of the total dry matter and 98 per ct. of the protein were fed to ducklings without any apparent ill effects.

During the first few weeks, growth was more rapid and equal growth made for less food (even at a lower cost for food) under a ration in which 60 per ct. of the protein was obtained from animal food, than under rations having respectively 20, 40 and 80 per cent. of the protein derived from this source.

Later growth was made at somewhat more economical expenditure of food under the "20 per ct." ration, but was slower. Under the rations containing larger proportions of animal food, marketable size was reached about two weeks sooner.

Results on the whole favored the use for the first few weeks of the ration in which 60 per ct. of the protein came from animal

* A reprint of Bulletin 259.

food, and later those containing larger and increasing proportions of grain foods.

INTRODUCTION.

In earlier experiments it was found that rations containing animal food gave better results than those consisting largely or altogether of grain food. With abundance of green forage and grit the result was the same. The more common grain foods contain more crude fiber and generally less nitrogenous matter, fat and mineral matter than the animal foods, and in ordinary rations disadvantage might come from undue proportions of these constituents. But when, by using an unusual number of foods, palatable rations were made to contain nearly equal proportions of these constituents, the advantage was still decidedly in favor of those containing animal food.

With chicks this advantage did not appear when care was taken to supply abundant mineral matter to the vegetable food ration. But with ducklings a ration entirely of vegetable origin always proved inferior; and it seems necessary with all except costly or very unusual feeding materials, to use considerable animal food for satisfactory results. In most of the feeding experiments referred to, from 35 to 40 per ct. of the protein in the efficient rations was derived from this source.

To learn how much animal food in the prepared commercial forms could be used without disadvantage, and what proportion it is ordinarily desirable to use, supplementary feeding trials were made. Results from some of these are herein reported.

No injury to the health of ducklings appeared at any time when different animal foods were moderately or quite freely used, even under a liberal feeding at one time of some animal meal that could not be fed to young chicks without disastrous results.

FIRST FEEDING TRIAL.

CONDITIONS.

Records from the feeding of two lots of ducklings of different ages on rations in which over nine-tenths of the dry matter and about 98 per ct. of the protein were derived from animal products follow in tabulated form. Sand was regularly added to the food, but nothing else except green alfalfa was fed besides

TABLE I.—DUCKLINGS FED RATIONS IN WHICH NINE-TENTHS OF DRY MATTER WAS FROM ANIMAL PRODUCTS.

LOT A.

No. days in period.	Average age at beginning of period.	Average weight at end of period.	No. of ducklings.	Average Per Fowl for Period. Meat meal.	Animal meal.	Milk albumen.	Blood meal.	Bone meal.	Sand.	Green alfalfa	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed	Cost of food for each lb. net gain in wt.	Dry matter in food for each lb. gain in wt.
	Wks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
28	2	2.3	10	38.7	28.0	8.4	8.1	8.1	9.7	23.8	45.4	21.5	12.2	1:0.9	4.1	3.2	.37	27.9	3.8	6.0	3.2
30	6	3.6	10	57.2	44.0	15.6	15.8	15.8	14.4	67.2	74.2	37.0	19.0	1:0.9	7.2	5.1	.58	20.3	3.2	13.7	7.5

LOT B.

No. days in period.	Average age at beginning of period.	Average weight at end of period.	No. of ducklings.	Meat meal.	Animal meal.	Milk albumen.	Blood meal.	Bone meal.	Sand.	Green alfalfa	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed	Cost of food for each lb. net gain in wt.	Dry matter in food for each lb. gain in wt.
28	7.0	5.2	8	51.9	80.3	17.2	15.8	15.8	17.4	45.5	82.0	51.2	24.2	1:0.9	8.1	6.4	.75	42.9	2.9	7.9	4.1
14	11.0	5.3	8	24.4	47.2	8.2	9.7	9.7	8.1	42.0	44.7	29.9	13.3	1:1.0	10.1	7.3	.83	2.9	1.2	—	—

the different dried ground animal by-products. These consisted of "meat meal," "animal meal," dried blood, bone meal and milk "albumen" (a by-product from the milk sugar factories). The ducklings in both lots were of somewhat inferior and weaker stock and those of lot "A" also late hatched, but at no time did any of them seem to suffer at all in health under the unusual ration.

The foods had the composition shown in the following table:

TABLE II.—COMPOSITION OF FOODS FOR LOTS A AND B.

FOOD.	Moisture.	Protein.	Ash.	Fiber.	N.-free extract.	Ether extract (fats).
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
"Meat meal"........	7.8	62.7	4.6	?	7.6	17.3
"Animal meal"......	5.8	31.4	39.8	?	5.7	13.3
Dried blood..........	11.0	85.1	3.0	?	.6	.3
Milk "albumen".....	10.0	38.6	30.9	?	20.0	.5
Bone meal...........	5.6	19.9	64.3	?	4.3	5.9
Green alfalfa.........	77.7	3.7	2.0	6.0	9.9	.7

RATIONS.

In the rations for both Lot A and Lot B during four weeks of feeding, 94 per ct. of the dry matter of 98 per ct. of the protein came from animal foods. During the last month for Lot A and the last fortnight for Lot B these foods supplied over 90 per ct. of the dry matter and nearly 97 per ct. of the total protein. In the ration for Lot A about 24 per ct. of the dry matter was represented by the ash constituents and in that for Lot B about 29 per ct. The nutritive ratio was excessively narrow.

RESULTS.

The birds in Lot A made a fairly rapid growth during four weeks without waste of food. During the next month growth was slower, and unprofitable. Lot B of older birds made good gains at fair expenditure of food during four weeks. For two weeks following there was slow increase in weight as is usual with birds of this age. Profitable growth would hardly be expected owing to the expensive foods used, but for a month with each lot the cost was not excessive, although the average cost of gain in weight was high.

THE EXPERIMENT PROPER.

CONDITIONS.

In another experiment four similar lots of ducklings were fed rations which differed according to the amount of animal food. The proportion of the total protein of the ration derived from this source was approximately 20 per ct. for Lot I, 40 per ct. for Lot II, 60 per ct. for Lot III and 80 per ct. for Lot IV. So far as earlier experience went this group seemed to overlap the limits of most efficient feeding. Whenever less animal food is used growth is usually too slow. When larger amounts are used the cost is excessive. The ducklings were hatched together and were from the same stock; all conditions except food being practically identical for the several lots, each of which included 28 birds.

FOODS.

The grain mixtures used were,—one, "Z" composed of 7 parts corn meal, 6 parts animal meal, 4 parts wheat middlings and 3 parts wheat bran;—and another "G," composed of 2 parts Chicago gluten meal and one part each of germ gluten meal and O. P. linseed meal. Salt was added to the extent of five ounces in every hundred pounds of each mixture. The other foods were animal meal, corn meal, wheat middlings, green alfalfa and bone ash. The bone ash was used to prevent any possible deficiency of total mineral matter in any ration; and to avoid any great differences in amount of ash, for the animal meal contained so much bone that rations in which it was freely used had a high percentage of ash constituents. The bone ash, which would be unnecessary for ordinary feeding, added considerably to the cost of the ration.

In the accompanying table is shown the composition of each food:

Table III.—Composition of Foods Used in Experiment.

Food.	Moisture.	Protein.	Ash.	Fiber.	N.-free extract.	Ether extract (fats).
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Mixture "Z"	13.0	20.3	13.8	3.1	44.4	5.4
Mixture "G"	11.1	33.8	2.6	5.3	41.2	6.0
Animal meal	8.6	39.7	40.0	1.3	1.4	9.0
Corn meal	16.6	9.1	1.3	2.0	66.9	4.1
Wheat middlings	15.8	14.5	2.3	3.3	60.0	3.5
Green alfalfa	80.2	4.5	1.9	4.7	7.7	1.0

VALUATIONS OF FOODS.

In estimating the cost of food, valuations were taken which approximated the market prices at the time of this feeding experiment. Corn meal was rated at $22.50 per ton, wheat middlings at $21, wheat bran at $19, animal meal at $35, Chicago gluten meal at $26, cream gluten meal at $29.50, linseed meal at $29, meat meal and bone meal at $30, blood meal at $50 per ton, milk "albumen" at 3 cents per pound, bone ash at 2 cents per pound and green alfalfa at $2 per ton.

The records from feeding and results averaged for periods of one week are given in the accompanying tables.

RATIONS.

The feeding experiment proper extended over a period of ten weeks, beginning with ducklings one week old. For the first three weeks for Lot I 12.8 per ct. of the dry matter in the ration was supplied by animal food from which 21.4 per ct. of the total protein in the ration was derived. The ash constituents represented 21.8 per ct. of the dry matter. For the following seven weeks 11.5 per ct. of the dry matter was from animal food from which 19.4 per ct. of the protein was derived. The ash constituted 21.2 per ct. of the dry matter.

For the first three weeks for Lot II 26.5 per ct. of the dry matter in the ration was supplied by animal food from which 41.9 per ct. of the total protein was derived. The ash constituted 23.7 per ct. of the dry matter, For the following seven weeks 25.1 per ct. of the dry matter was from animal food from which 40.8 per ct. of the total protein was derived. The ash constituted 23.8 per ct. of the dry matter.

TABLE IV.—DUCKLINGS FED ON RATIONS WITH ABOUT TWENTY PER CT. OF THE PROTEIN FROM ANIMAL FOOD.

LOT I.

No. days in period.	Average age at beginning of period.	Average weight at end of period.	No. of ducklings.	Average Per Fowl for Period. Mixture Z.	Mixture G.	Corn meal.	Wheat midlings.	Bone ash.	Sand.	Alfalfa	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed	Cost of food for each lb net gain in wt.	Dry matter in food for each lb. gain in wt.
	Wks.	*Lbs.*		*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*	*Ozs.*		*Ozs.*	*Ozs.*	*Cts.*	*Ozs.*	*Ozs.*	*Cts.*	*Lbs.*
7	1	.4	28	4.1	3.3	.4	.4	1.1	1.0	.5	2.0	1.8	.4	1:2.5	1.4	1.2	.11	3.3	3.6	3.6	2.5
7	2	.8	28	7.4	5.7	.6	.6	1.9	1.9	1.0	3.6	3.1	.8	1:2.5	2.5	2.1	.19	6.0	3.4	3.5	2.5
7	3	1.2	28	7.3	7.6	.6	.6	2.5	1.9	2.0	4.3	3.8	.9	1:2.4	3.0	2.4	.22	6.6	2.4	3.7	2.6
7	4	1.8	28	11.1	10.0	.9	.9	3.3	2.8	2.5	5.9	5.2	1.3	1:2.4	4.1	3.4	.30	8.9	2.3	3.8	2.7
7	5	2.4	28	12.7	12.9	1.1	1.1	4.3	3.2	4.0	7.4	6.5	1.6	1:2.4	5.2	4.2	.37	9.7	2.0	4.3	3.0
7	6	2.8	28	14.0	15.3	1.2	1.2	5.1	3.5	5.0	8.5	7.5	1.8	1:2.4	6.0	4.8	.43	7.5	1.9	6.4	4.5
7	7	3.7	28	18.2	17.2	1.5	1.5	5.7	4.5	5.0	10.1	8.8	2.2	1:2.4	7.0	5.8	.51	14.3	1.8	4.0	2.8
7	8	4.0	28	13.9	14.4	4.6	1.1	4.8	3.5	6.0	8.5	7.3	1.9	1:2.6	6.4	5.1	.44	3.1	1.3	15.8	11.5
7	9	4.4	28	14.9	14.2	5.0	1.2	4.7	3.8	6.0	8.7	7.4	1.9	1:2.6	6.6	5.2	.45	7.8	1.2	6.5	4.7
7	10	4.7	28	14.5	14.2	4.9	1.2	4.7	3.6	8.0	8.7	7.3	1.9	1:2.6	6.8	5.2	.45	4.5	1.1	11.2	8.2

TABLE V.—DUCKLINGS FED RATIONS WITH ABOUT FORTY PER CT. OF THE PROTEIN FROM ANIMAL FOOD.
LOT II.

No. days in period.	Av. age at beginning of period.	Av. weight at end of period.	No. of ducklings.	Average Per Fowl for Period. Mixture Z.	Mixture G.	Corn meal.	Wheat middlings.	Animal meal.	Bone ash.	Sand.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed	Cost of food for each lb. net gain in wt.	Dry matter in food for each lb. gain in wt.
	Wks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.5	28	4.3	2.0	.3	.3	1.1	.7	1.1	.5	2.1	1.8	.5	1:2.2	1.3	1.1	.10	3.7	3.3	3.2	2.1
7	2	.8	28	6.3	3.7	.5	.5	1.7	1.2	1.6	1.0	3.4	2.9	.8	1:2.2	2.1	1.8	.17	5.7	2.8	3.3	2.2
7	3	1.4	28	9.8	6.1	.8	.8	3.1	2.3	2.5	2.0	5.6	5.1	1.3	1:2.1	3.6	3.0	.28	9.8	2.6	3.2	2.1
7	4	2.1	28	13.4	8.9	1.1	1.1	4.7	3.3	3.3	2.5	8.0	7.4	1.8	1:2.1	5.0	4.2	.40	11.1	2.4	4.1	2.7
7	5	2.9	28	18.4	11.9	1.6	1.6	5.5	4.4	4.8	4.0	10.5	9.6	2.2	1:2.1	6.8	5.6	.53	13.0	2.2	4.6	3.0
7	6	3.5	28	17.0	13.2	1.4	1.4	7.2	4.9	4.3	5.0	11.4	10.7	2.5	1:2.2	7.2	5.9	.57	6.3	1.8	10.2	6.6
7	7	4.5	28	21.6	12.1	1.8	1.8	6.0	4.5	5.4	5.0	11.5	10.4	2.6	1:2.2	7.6	6.2	.58	14.8	1.5	4.4	2.9
7	8	4.6	28	15.2	12.1	5.0	1.3	7.1	4.5	3.8	6.0	10.9	10.0	2.5	1:2.2	7.3	5.9	.55	1.8	1.3	—	—
7	9	4.7	28	17.9	15.3	7.1	1.8	4.9	5.7	5.4	6.0	11.9	10.8	2.7	1:2.4	8.4	6.8	.62	2.1	1.5	—	—
7	10	5.4	28	14.6	7.0	4.9	1.2	4.8	2.6	3.6	8.0	8.2	7.0	2.0	1:2.4	6.1	4.6	.42	10.6	.9	4.4	3.1

TABLE VI.—DUCKLINGS FED RATIONS WITH ABOUT SIXTY PER CT. OF THE PROTEIN FROM ANIMAL FOOD.
LOT III.

No. days in period.	Av. age at beginning of period.	Av. weight at end of period.	No. of ducklings.	Average per fowl for period. Mixture Z.	Mixture G.	Corn meal.	Wheat middlings.	Animal meal.	Bone ash.	Sand.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.	Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed	Cost of food for each lb. net gain in wt.	Dry matter in food for each lb. gain in wt.
	Wks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Cts.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.5	28	4.8	1.4	.4	.4	2.9	.5	1.2	.5	2.7	2.4	.6	1:1.9	1.6	1.3	.14	4.4	3.5	3.4	2.1
7	2	1.0	28	8.9	1.8	.7	.7	4.0	.6	2.1	1.0	4.2	3.5	1.0	1:2.0	2.5	2.1	.21	7.7	2.8	3.1	2.0
7	3	1.6	28	9.9	3.6	3.3	.8	5.9	1.8	2.5	2.0	6.1	5.7	1.5	1:2.1	3.9	3.3	.31	10.4	2.4	3.4	2.2
7	4	2.3	28	9.1	5.5	3.2	.8	10.9	2.7	2.4	2.5	8.6	8.6	2.0	1:1.7	5.0	4.2	.43	10.8	2.1	4.5	2.7
7	5	3.0	28	15.8	4.7	5.3	1.3	10.7	2.3	4.0	4.0	9.9	9.1	2.4	1:2.1	6.3	5.2	.50	11.0	1.9	5.1	3.3
7	6	3.5	28	15.9	7.3	5.3	1.3	14.1	3.6	4.0	5.0	12.2	11.9	2.9	1:1.9	7.5	6.3	.62	7.2	1.9	9.7	6.0
7	7	4.5	28	20.8	6.7	6.9	1.7	13.8	3.4	5.2	5.0	13.1	12.1	3.1	1:2.1	8.3	6.9	.67	17.0	1.7	4.4	2.8
7	8	4.5	28	15.9	7.3	5.3	1.3	11.4	3.6	4.0	6.0	11.2	10.8	2.7	1:2.0	7.3	5.9	.57	—	1.3	—	—
7	9	5.5	28	20.2	5.7	6.7	1.7	12.6	2.9	5.0	6.0	12.2	11.1	3.0	1:2.1	8.0	6.5	.62	16.6	1.3	4.2	2.5
7	10	5.4	28	16.4	4.6	5.5	1.4	10.6	2.3	4.1	8.0	10.1	9.2	2.5	1:2.1	7.0	5.4	.51	—	1.0	—	—

TABLE VII.—DUCKLINGS FED RATIONS WITH ABOUT EIGHTY PER CT. OF THE PROTEIN FROM ANIMAL FOOD.
LOT IV.

No. days in period.	Average age at beginning of period.	Average weight at end of period.	No. of ducklings.	Average Per Fowl for Period.													Av. gain in wt. per fowl during period.	Dry matter in food per day for each lb. live wt. fed.	Cost of food for each lb net gain in wt.	Dry matter in food for each lb. gain in wt.
				Mixture Z.	Corn meal.	Wheat middlings.	Animal meal.	Sand.	Alfalfa.	Protein in food.	Ash in food.	Fats in food.	Approximate nutritive ratio.	Total food per day.	Dry matter in food per day.	Cost of food per day.				
	Wks.	Lbs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.		Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Cts.	Lbs.
7	1	.5	28	5.1	.5	.5	3.9	1.5	.5	2.7	2.3	.7	1:1.8	1.5	1.3	.13	4.2	3.7	3.5	2.1
7	2	1.0	27	8.8	.7	.7	7.7	2.2	1.0	5.1	4.3	1.2	1:1.6	2.7	2.3	.24	8.0	3.0	3.4	2.0
7	3	1.6	27	9.7	3.2	.8	10.7	2.4	2.0	6.7	5.7	1.7	1:1.7	3.8	3.1	.33	8.6	2.4	4.2	2.5
7	4	2.3	27	14.0	4.7	1.2	17.7	3.5	2.6	10.6	9.2	2.6	1:1.6	5.7	4.8	.51	10.5	2.5	5.4	3.2
7	5	3.0	27	16.7	5.6	1.4	17.9	4.2	4.1	11.4	9.6	2.8	1:1.8	6.5	5.4	.55	11.6	2.0	5.3	3.2
7	6	3.7	27	17.0	5.7	1.4	23.0	4.3	5.2	13.5	11.7	3.3	1:1.6	7.5	6.1	.65	11.1	1.8	6.5	3.8
7	7	4.5	27	20.9	7.0	1.7	19.6	5.2	5.2	13.1	11.0	3.3	1:1.9	7.8	6.3	.64	12.3	1.6	5.9	3.6
7	8	4.6	27	19.7	6.6	1.6	23.6	4.9	6.2	14.5	12.4	3.6	1:1.7	8.2	6.7	.70	3.1	1.5	——	15.2
7	9	5.1	27	20.6	6.8	1.7	18.3	5.1	6.2	12.6	10.4	3.1	1:1.9	7.7	6.1	.61	6.9	1.3	9.9	6.2
7	10	5.2	27	17.5	5.8	1.4	17.5	4.4	8.3	11.6	9.7	2.9	1:1.8	7.2	5.6	.56	2.5	1.1	——	15.7

For the first three weeks for Lot III 38.5 per ct. of the dry matter and 59.4 per ct. of the total protein came from animal food. The ash represented 24.5 per ct. of the dry matter. For the following seven weeks 38.4 per ct. of the dry matter and 60.0 per ct. of the total protein came from animal food. The ash constituted 25.8 per ct. of the dry matter.

For the first three weeks for Lot IV 57 per ct. of the dry matter in the ration came from animal food which supplied 79.4 per ct. of the total protein. The ash made up 26.2 per ct. of the dry matter. For the following seven weeks 61.5 per ct. of the dry matter and 78.9 per ct. of the protein came from animal food. The ash constituents formed 25.7 per ct. of the dry matter.

The rations were all narrower in nutritive ratio than is necessary. Differences between them in this respect were not great, nor as much as would exist in other respects if widened to any extent with foods available, giving for some an undesirable proportion of fat.

RESULTS WITH EACH LOT.

The ducklings in Lot I having the "20 per ct. ration," (one in which about 20 per ct. of the protein was derived from animal food) during the first three weeks made an average gain in weight of 15.9 ounces, at the rate of one pound for every 2.5 pounds of dry matter in the food—and at a food cost of 3.6 cents per pound gain. During the remaining seven weeks the average gain was 55.8 ounces, one pound for every 4.2 pounds of dry matter in the food, at a cost of 6.0 cents per pound gain. For the first seven weeks of feeding, up to the age of eight weeks, the average gain in weight was 56.3 ounces, one pound for every 3.0 pounds dry matter in the food, the food cost being 4.2 cents per pound gain. For the entire period covered by the experiment the total average gain was 71.7 ounces, at the rate of one pound for every 3.9 pounds of dry matter in the food. The food cost 5.4 cents per pound gain.

The ducklings in Lot II having the "40 per ct. ration," made an average gain of 19.1 ounces during the first three weeks, at the rate of one pound for every 2.2 pounds of dry matter in the food; the cost being 3.3 cents per pound gain. For the following seven weeks the average gain was 59.7 ounces, one pound for every 4.6 pounds dry matter in the food and at a food cost of 6.9 cents per pound. During the first seven weeks of feeding the average gain was 64.2 ounces, one pound for every 3.0 pounds of dry matter in the food, at a food cost of 4.6 cents per pound gain. For the entire period of experiment the average gain in weight was 78.8 ounces, at the rate of one pound for every 4.0 pounds of dry matter in the food. The food cost was 6.0 cents per pound gain.

In Lot III having the "60 per ct. ration" the average gain during the first three weeks was 22.5 ounces, at the rate of one pound for every 2.1 pounds of dry matter in the food—the food cost being 3.3 cents per pound gain. For the following seven weeks the average gain was 60.3 ounces, at the rate of one pound for every 4.7 pounds of dry matter in the food—the cost being 7.3 cents per pound. During the first seven weeks of feeding the average gain was 68.4 ounces, one pound gain for every 3.0 pounds of dry matter in the food at the cost of 4.7 cents per pound gain. For the entire period the average gain was 82.7 ounces at the rate of one pound for every 4.0 pounds of dry matter in the food and at the food cost of 6.2 cents per pound.

In Lot IV having the "80 per ct. ration" the average gain in weight during the first three weeks was 20.8 ounces, at the rate of one pound for every 2.3 pounds of dry matter in the food; the food cost being 3.8 cents per pound gain. For the remaining seven weeks the average gain was 57.9 ounces at the rate of one pound for every 5.0 ounces of dry matter in the food, and at a cost of 8.2 cents per pound. During the first seven weeks of feeding the average gain in weight was 66.2 ounces at the rate of one pound for every 3.1 pounds of dry matter in the food. The cost was 5.2 cents per pound. For the entire period the average gain in weight was 78.7 ounces at the rate of one pound for every 4.2 pounds of dry matter in the food. The food cost was 7.0 cents per pound gain.

RESULTS IN GENERAL.

On the average for the entire period the ratio of the dry matter of the food consumed to the gain in weight was about the same for the Lots I, II, and III, and somewhat higher for Lot IV. In relation to the cost of growth the different lots stood in the same order as to the relative amounts of animal food in the ration. But in rate of growth Lot I, having the least animal food, was considerably behind the others. The growth made by Lots II and IV exceeded it by nearly 10 per ct. and that made by Lot III by over 15 per ct.

For the first three weeks of feeding the advantage lay plainly with Lot III having the "60 per ct. ration." The food was used more efficiently, the cost was as low as with any and growth was fastest, being over 40 per ct. faster than for Lot I, about 18 per ct. faster than for Lot II and 8 per ct. faster than for Lot IV.

For the first seven weeks of feeding, up to the age of eight weeks, the amount of water-free food required per pound gain was almost exactly the same for three lots and a little higher for Lot IV. The food cost of growth varied in the same order as did the rations in relation to amount of animal food, but not in the same ratio. Growth was most rapid for Lot III and exceeded that of Lot I by over 20 per ct., the birds averaging at eight weeks about 4.2 pounds weight to about 3.5 pounds for Lot I, 4.0 pounds for Lot II and 4.1 pounds for Lot IV.

IN CONCLUSION.

After the close of the ten weeks' feeding under the four rations, each lot was fed on a more fattening ration, the same for all. This consisted of about equal amounts of the mixture "Z" and corn meal, with green alfalfa. During the first week under this ration the birds of Lot I made a rapid gain at moderate expenditure of food; about one pound increase for every 3.3 pounds of dry matter in the food, indicating that, while rapid growth had been arrested under the experimental ration, attainment of good size had been delayed rather than prevented. This has been observed under other rations deficient in either nitrogenous or mineral matter; although, in general, birds which had suffered under the disadvantage of inefficient rations for long, failed to develop afterward as well as others.

At the age of 12 weeks the largest individuals in Lot IV weighed over 7.2 pounds, exceeding the largest of Lot I, which weighed about 6.1 pounds, by 18 per cent. The largest in Lots II and III were intermediate in size. In no lot, however, was development noticeably uneven.

COMMENTS.

Without considering the cost of food the best results accompanied the use of the ration in which 60 per ct. of the protein came from animal food. At the values stated for the several foods, or at the market prices usually holding, ducklings were grown more cheaply under the ration containing the least animal food. The growth was so slow, however, and the advantage of getting birds quickly ready for market is often so decided, that greater profit would lie with the more costly ration, for in this case about two weeks' time was saved in getting birds to the same weight, and from an equal number hatched 15 per ct. more poultry was produced in the same time. There was ready for market at the same time about 145 pounds from Lot III and about 125 pounds from Lot I, equal in number to Lot III.

So far as this one experiment goes, it seems from a study of the results that it will pay to feed freely of animal food during the first three to five weeks, and depend after that more on increasing proportions of the cheaper grain foods. The exact proportions most profitable to use will vary considerably at different times according to the food supply and the demand for the product.

REPORT

OF THE

Department of Bacteriology.

H. A. Harding, *Dairy Bacteriologist.*

M. J. Prucha, *Assistant Bacteriologist.*

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REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

A SWELLING OF CANNED PEAS ACCOMPANIED BY A MALODOROUS DECOMPOSITION.*

H. A. Harding and J. F. Nicholson.†

SUMMARY.

1. The value of the peas canned in the State of New York in 1900 was estimated at $1,473,912.

2. Swelling of the canned peas is the occasion of much loss to the industry.

3. This swelling is brought about by certain species of bacteria, of which the spores have survived the heating process.

4. The spores of the resistant form which was studied were destroyed on heating 2 lb. cans of peas at 240° F. ($115\frac{5}{9}$° C.) for 30 minutes.

5. When tested on a large scale at a factory this heating destroyed the germs without injury to the commercial quality of the goods.

INTRODUCTION.

With the development of the country there has sprung up a number of industries which utilize the raw materials of the farm. Of these the cheese factory and creamery have long been considered as coming within the field of experiment station activity and a large amount of work is being annually directed toward the solution of their problems. At the same time the equally perplexing problems met with in condensing milk and in pre-

*Reprint of Bulletin No. 249.

†Resigned as assistant bacteriologist of this station on June 23, 1903, to accept similar position at the Oklahoma Agricultural College and Experiment Station.

serving and pickling fruit and vegetables have been very generally neglected, although in the last analysis all of these industries stand in essentially the same relation to the farmer and the consumption of his products.

FRUIT AND VEGETABLE CANNING IN NEW YORK.

The growth of this industry has been so rapid that any reliable information is out of date by the time it is available. The most accurate source of recent information is the census taken in 1900, but this can only give a general idea of present conditions.

In 1900 there were reported 511 establishments in the State of New York engaged in canning fruit and vegetables. This was a gain of 352 since 1890. These factories used in a year $5,592,463 worth of materials, and turned out products valued at $8,975,321. It was estimated that 65 per ct. of the cost of materials, or $3,635,100 was for farm products. During this year these canning establishments put up 36,073,696 lbs. of peas in New York, valued at $1,473,912. In comparison with the other states New York stood first in the value of canned peas, second in the value of canned vegetables and third in the value of canned fruits.

LOSSES IN CANNING.

From the beginning of the canning industry there have been losses because a portion of the goods failed to keep. There is always a small loss due to leaky cans, but there are often losses too large to be accounted for on this basis. These failures are commonly spoken of by the canners as "swells" and "sours."

Cans are said to be "swelled" or fermented when the normally depressed ends bulge outward. When such cans explode or are opened the material contained is usually decomposed, vile smelling and worthless as food. There are at least two classes of exceptions to this description of the contents: Certain fruits often bulge slightly when held over winter in storage, but on opening they are found unchanged and fit for food; and cans which have undergone souring will often swell if kept for a time in a warm place.

Since it could not be overlooked, swelling has been known as long as canning has been practiced, and losses of this kind have been strong incentives for improving methods. "Soured" cans give no external evidence of being abnormal; but when opened the contents emit a sour smell and have an acid flavor. With peas, the odor is not disagreeable, the liquor is milky and the flavor ranges from faint to decidedly acid. Where the acid is formed after the cans are heated, especially if the goods are held some time at 70° F. or above, enough gas is formed to cause the ends to bulge slightly. In such cases the cans are commonly classed as "swells." However, in case the acid is produced before the cans are heated or where the cans have been held at low temperature no change is apparent until the cans are opened by the consumer. As long as the public was not educated to expect fine quality, a considerable amount of sour goods was undoubtedly consumed without question. Now the consumers have become more discriminating and the increased protest against sour goods is one of the results.

CAUSE OF THESE LOSSES.

The fact that fermentations in general are so commonly caused by the lower forms of plant life leads to the widespread belief that all the difficulty in keeping canned goods can be attributed to the same cause. While it is probably true that a large proportion of the swelling and souring is due to the growth of bacteria within the cans undoubtedly exceptions will be found. It is also true that there are a number of different species of bacteria which produce swelling or souring of the same vegetables in different factories.

FACTORS WHICH ASSIST IN KEEPING CANNED GOODS.

There are several factors which combine to make commercial canning possible. Fresh and clean fruits and vegetables are desirable because they carry smaller numbers of the germs which it will be necessary to destroy. This means cleanliness in the utensils and persons with which the materials come in contact before entering the cans. Pure air is desirable, especially for the workmen, but its effect on the product has often been over-estimated.

Where large quantities of sugar are used with fruits the sugar tends to restrain the growth of germs which may be present.

This is the basis of the keeping quality of household preserves. Maple syrup which weighs 11 lbs. to the gallon contains about the minimum amount of sugar which will prevent fermentation under favorable conditions. Even maple syrup kept warm commonly ferments. In the quantities used with vegetables the sugar increases, rather than retards, fermentation.

In their zeal to sell saccharin the agents often claim high germicidal properties for this substance. As used in peas, the germicidal property of saccharin, if present, is too slight to be of practical use. Stress is also laid upon the point that saccharin does not break up into gas under the influence of bacteria. As the sugar in the peas themselves will furnish sufficient gas to explode the cans this item is of little value.

The acid in fruits and certain vegetables increases the effectiveness of the heating in a marked degree. In practice, pieplant keeps with far less heating than is required by asparagus. Peas which had soured after processing for 30 minutes at 236° F. were heated for a few minutes at 212° F. It was found that in many cases in the presence of the acid, this slight heating had killed all the germs.

Antiseptics have held, in the past, a considerable place in the fight which canners have made against fermentation. They are still used to a sufficient extent to induce liberal advertising by the manufacturers of certain proprietary compounds. An analysis[1] of some of the leading compounds of this class has shown that they are combinations of a few well known chemicals of which formalin, boracic acid and salicylic acid are the most common examples. If canners *will* use these chemicals they would display business foresight in buying them in pure rather than in proprietary form since they can be obtained pure for much less money.

The objection to the use of these substances because of their effect upon digestion is well known and there is a growing tendency to legislate against their use. It has been maintained that the use of antiseptics is unavoidable in certain departments of canning; but the list of substances which have not been successfully canned without the use of antiseptics is small. The use of

[1] Chemical Composition of Food Preservatives. Iowa Agr. Exp. Sta. Bul. 67. 1902.

such material in many cases is an admission of either carelessness or ignorance on the part of the canner.

It is a matter of common observation that the absence of a vacuum means trouble. From this has grown the idea that the vacuum itself prevents decomposition. Nothing could be farther from the facts. The souring of peas often progresses to a point where the peas are worthless before the vacuum is destroyed. Moreover, cans of peas will keep satisfactorily in free contact with the air if, before processing, the opening is provided with a cotton plug so as to prevent germs from entering.

The vacuum is useful in decreasing the tension in the can in connection with the heating and its absence indicates a leak which will allow germs to enter.

Commercial canning depends very largely upon heat as a means of preventing undesirable changes; and the progress of the business has been marked by improvements in the means of heating and in the knowledge of the effects of various degrees of heat. Beginning with open tanks of water which were limited to 212° F. there has been developed the closed kettle where all temperatures up to 250° F. are in use. Prescott and Underwood stated[2] that when working at 236° F. that temperature was found at the center of a 2 lb. can of standard packed peas in 10 minutes while it took 40 minutes heating at 250° F. to raise the center of a like can of corn to 236° F.

BACTERIA AND THEIR ACTION.

For convenience members of the plant world are often referred to by groups. The members of one of these groups, characterized by their small size and simple form are referred to as bacteria. Like mould spores and yeast cells the individual bacterium (plural bacteria) is too small to be seen by the unaided eye but like both mould and yeast it often grows into a mass which can be readily seen.

Food can be used by plants only when it is in solution, so that the germs live, not on the vegetables directly, but upon the soluble material in the cans. By means of enzymes which they secrete they are able to soften the solid vegetables. They all

[2] Paper before Rochester meeting of Canners's Association. *Trade* **23**: No. 29, Feb. 22, 1901; also *Canner and Dried Fruit Packer* of same date.

require oxygen in some form and give off carbon dioxide, which is partly responsible for the bulging of the cans. Sugar in moderate quantities is especially useful to those growing in canned goods since it furnishes them with oxygen.

The character of the decomposition depends partly upon the nature of the original compounds and partly upon the form into which the particular germ breaks them in extracting the portion desired as food. The germs causing the swelling of peas break up the sugar in such a way as to produce a large amount of gas and a small amount of acid. The ones producing souring in peas break up the sugar so as to leave a large amount of acid and little or no gas.

BACTERIA ARE OF DIFFERENT KINDS.

In objects which are only about 1-25000 of an inch wide and a few times longer than broad there is but a limited amount of information to be derived with a microscope. However some forms are round like miniature peas while others are rod-like. The latter differ slightly in plumpness and in the position and appearance of their spores. The spores are very resistant bodies formed within the cells and capable of starting growth anew at some later time. The growing cells are killed by any ordinary amount of cooking but the spores often survive and cause trouble.

The bacteria which are capable of destroying canned goods are not only of different species but, what is of more importance to the canners, the spores of different species are capable of withstanding different amounts of heating. As a result of this, canners who have been processing successfully at a low temperature for a number of seasons suddenly find themselves in trouble when a more resistant species gets into the cans.

Until outbreaks of swelling and souring of a given vegetable have been studied in a number of factories we will not be able to draw safe general conclusions as to what temperature can be absolutely relied upon to keep the given vegetable under all conditions. While these facts are being ascertained the safest practical plan will be to give the cans the amount of heating required to kill the most resistant species known to trouble the particular vegetable and as much more as the vegetable will stand without injury to its commercial quality.

SWELLING OF CANNED PEAS.

CAUSE DETERMINED.

INTRODUCTORY NOTES.

In peas, acid is lacking, the amount of sugar and nitrogen is such as to favor fermentation, and heat alone must be relied upon to prevent decomposition. Add to this the fact that heat penetrates the cans rather slowly and it is seen why peas are among the most difficult vegetables to can satisfactorily.

In 1902 our attention was called to a serious outbreak of swelling in the product of a large factory. In connection with this work we attempted to determine three points: (1) The cause of the trouble, (2) the amount of heating necessary to obviate the trouble, (3) the limit of heating which was practical without injury to the commercial quality of the peas.

In order to test these results under commercial conditions and in order to determine the limit of heating which peas would stand without injury it was necessary to work with fresh peas at a factory. The Geneva Preserving Co. very kindly gave us every facility for carrying out this work at their plant and in this connection we canned a ton of peas, including early and late varieties, under actual factory conditions.

The lively and helpful interest which all members of the force took in the work was one of its most pleasant features and to them we return our sincere thanks. We are especially indebted to Manager Thorne, upon whose experience we have drawn largely throughout the progress of the work. We are also indebted to the canners of the State who by furnishing information on various points have enabled us to give an additional test to the practicability of our conclusions.

PREVIOUS STUDY OF THIS PROBLEM.

The swelling of canned peas was, so far as we have been able to learn, the first trouble of this nature to be successfully attacked by modern science. In 1895 Russell[3] studied an outbreak in a Wisconsin factory. He found that the swelling was the result of the action of germs which had survived the heating process and

[3] Gaseous Fermentations in the Canning Industry. Wis. Agr. Exp. Station 12th Ann. Rept., 1895: p. 227.

that the trouble could be prevented by increasing the temperature of processing.

While he gave but a hint as to the characteristics of the causal organism it would seem to be slightly different from the one with which we had to deal in the present outbreak.

THE OUTBREAK AT THE FACTORY.

The New York factory where the outbreak occurred had been processing peas in 2 lb. cans at 230° F. (110° C.) for 30 minutes for a number of seasons with good results. In 1902 they began on Alaska peas on June 20; and on July 10 swelling was evident in the stock room.

At this date a portion of the peas had already been shipped but those remaining in stock and not swelled were reheated at 238° F. ($114\frac{4}{9}$° C.) for 35 minutes. After this heating, all cans where the fermentation had started remained bulged on cooling. Those where it had not yet started were rendered sterile. The loss was practically total on all goods which had been shipped and in those reheated graded down to almost nothing on the pack of the preceding day. An examination of the reheated goods showed that they were in good condition except for a slight cooked taste due to the double heating. During the remainder of the season the peas were processed at 238° F. ($114\frac{4}{9}$° C.) for 35 minutes with very little loss.

THE SWELLED CANS.

Externally the cans presented the usual bulged appearance, the bulge showing more quickly at blood heat and increasing with lapse of time. In some cases the side seams gave way, in others the tops were blown off, widely scattering the contents. The peas emitted a disagreeable stench tinged with the odor of hydrogen sulphide. The bodies of the peas were mushy and the skins inflated with gas, like miniature balloons. The liquor was darkened and of a greenish tinge due to the small particles of the ruptured peas.

Occasionally cans were found which did not agree with this description. These were usually but slightly swelled and the odor of the contents was acid but not especially disagreeable. The peas appeared about normal but the liquid was distinctly milky and had a sharp, acid taste. A very few cans gave evidence of a mingling of these two forms of decomposition.

BACTERIA IN THE SWELLED CANS.

A microscopical examination of the juice from a swelled can showed that there were large numbers of bacteria present, while a like examination of a good can failed to show any bacteria.

Some of the sour cans contained a round or coccus form while other sour cans contained a rod form. The coccus form was studied sufficiently to show that it would not only sour cans of peas when artificially introduced but that when kept at blood heat these cans would commonly bulge.

The vile-smelling cans which made up more than 99 per ct. of the trouble all contained a rod form. This was plumper than those observed in the sour cans and in many cases was distinguished by a swelling at one end giving it the appearance of a drum stick.

BACTERIA CAUSE THE SWELLING.

The plump rod form having swollen ends was in many cases the only form to be found in the swelled cans. From such cans cultures were prepared at the laboratory and this germ separated from all other forms. A considerable number of cans of sterile peas were vented and a part of them received a culture of this germ. All were now resoldered and kept at blood heat. All of the inoculated cans swelled within 24 hours. In many cases the tension became sufficient to burst the cans. The cans which had been vented and resoldered without inoculation did not swell. An examination of the inoculated, swelled cans showed only the single form present.

These facts, then, identify the causal organism: (1) The finding of large numbers of a certain species of bacteria in spoiled canned goods while satisfactory goods are sterile; (2) the isolation and study of this germ in pure culture; (3) the inoculation of sound goods with these cultures and the production of the original trouble; (4) the reisolation of the germ from these goods and (5) the determination that it is the original species. These points complete the cycle of proof required to establish the fact that the original trouble was due to the activity of this germ.

In this case, we can apply the additional test that when inoculated into sound cans the suspected germ should be able to withstand the amount of heating to which the spoiled cans were originally subjected. Accordingly sterile cans were carefully opened, inoculated with pure cultures of the rod form from the spoiled cans and resoldered. The cans were then processed at 230° F. for different lengths of time.

TWO POUND CANS OF PEAS HEATED TO 230°F. (110°C.) AT LABORATORY.

Time in minutes	20	25	30	35	40
No cans heated	6	6	6	6	3
No. cans swelled	5	6	1	0	0
Percentage swelled	83	100	16	0	0

These cans were not kept under observation after about 10 days since at that time it was evident that this germ was capable of surviving a processing at 230° F. (110° C.) for 30 minutes. Had they been observed longer probably other cans would have swelled, since in later work we found that a considerable number of experimental cans swelled even after being kept at 80° F. ($26\frac{6}{9}$° C.) for two months.

From all this it would seem fair to conclude that the rod-like spore-bearing form found in the cans which had swelled at the factory was the cause of the swelling.

DESCRIPTION OF THE CAUSAL ORGANISM.

Form.— The rods are 4-6 long by 1.5-1.8μ wide and usually occur singly.

Stain.—Rods readily take the ordinary stains but do not take the Gram stain.

Spores.—The oval spores, one in a cell, are usually near the end of the rod. The rod swells at the point where the spore is to appear before the latter is visible. The ripened spore has a great diameter than the original rod. Spores are formed so freely that a culture is rarely free from them, new ones being formed before all of the old ones have sprouted. They often make up more than 50 per ct. of old cultures.

Motility.—Young cultures are actively motile and even the swollen rods in which the spores are forming sometimes swim about. Each rod is provided with several peritrichic flagella.

Culture characteristics.—So far as tested this germ failed to grow in contact with the air. Even where oxygen was excluded it grew poorly or not at all on the ordinary peptone culture media. The addition of sugar stimulated the growth. Cane sugar dextrose and lactose are broken up with the formation of gas and acid. Growth on lactose agar is scanty, white and often in discrete colonies. On lactose gelatin, stab growth is not visible but after a considerable interval circular liquified areas appear within the body of the gelatin.

Temperature exerts a marked influence upon the rate of growth. At 22° C. (71.6° F.) growth on lactose agar slopes appears only after two to three weeks while at 37° C. (98.6° F.) it is equally abundant in 2-5 days.

The vigor of growth is closely connected with the nitrogenous part of the media. The juice from canned peas or broth made by cooking ordinary white beans gave more vigorous growth than ordinary lactose bouillon. The fluid became turbid in 2-3 days at 37° C. (98.6° F.) with later formation of a pale sediment. There is a rapid and fairly abundant growth at this temperature of mass cultures upon media made by the addition of agar and salt to either the pea or the bean juice.

REMEDY APPLIED.

AT WHAT TEMPERATURE SHOULD PEAS BE PROCESSED.

The true cause of this outbreak having been established the next step was to determine the amount of heating necessary to destroy this organism when present in the cans. The use of 230° F. (110° C.) or any higher temperature would undoubtedly accomplish this provided the heating was continued a sufficient length of time.

The function of processing peas is twofold. First it must insure the preservation of the goods; second it should cook them just short of the amount required before consumption. Provided it does not injure the quality of the peas a high temperature is preferable since it shortens the time required for processing and thereby relieves the most congested part of the factory.

FACTORY PRACTICE.

In selecting a desirable temperature no more satisfactory guide could be expected than a summary of the practice of the canners of the State, since in many cases this represents the results of 20 years' practical experience. Accordingly blanks were sent to all the canners of the State known to be packing peas. Canners have been so frequently charged with keeping their methods secrete that the promptness of the replies came as an agreeable surprise. With one or two exceptions the desired information was furnished by every canner and often accompanied by an expression of interest and an offer of cooperation.

DETAILS OF PROCESSING PEAS, FROM REPORTS OF NEW YORK PEA CANNERS, 1902.

Temperature.	Number of factories.	Time Processed in Minutes.										
		10	15	20	25	30	35	40	45	50	55	60
Deg. F.												
230	2				1	2	1					
235	3					1	2					
236	3		1	1	1	3	1					
238	2			1	1	1	2	1				
240	25	5	8	11	15	15	12	5	1	1	1	1
244	1						1					
246	2			1	1	1	1	1				
250	1						1					

This table is based upon the replies of 1902 and shows the situation at a glance. It includes the returns from 39 factories but really represents a much larger number since the large companies commonly filled out a single sheet to cover their numerous branches. The common practice is to use a single temperature and vary the length of exposure according to the condition of the peas. Since 240° F. ($115\frac{5}{9}$° C.) was so commonly used it was taken as the most desirable temperature for further work.

THE EFFECT OF 240° F. ($115\frac{5}{9}$° C.) ON THE GERMS.

In order to test this matter under satisfactory conditions the work was carried on at the factory. Each can was inoculated with a large number of spores of the gas-forming germ.

The inoculations were made as the cans came from the filler and they were treated in the usual manner in other particulars. They passed to the processing room within an hour and there their method of treatment differed from the normal only in that they were heated for special lengths of time. After heating they were dropped at once into a stream of cold running water and thoroughly cooled.

The largest size and smallest size of Alsaka peas were used and the medium size of Advancers. They were run in batches of 50 cans of each size at each temperature. The Alaska peas were run on July 8 and the Advancers July 13. The cans were removed to the laboratory where they were kept under observation for 8 months. The temperature of the storeroom was kept between 80° F. (26$\frac{6}{9}$° C.) and 90° F. (32$\frac{2}{9}$° C.) for a number of months.

TWO POUND CANS OF PEAS HEATED AT 240°F (115$\frac{5}{9}$°C.) AT FACTORY.

Time in minutes	10	15	20	25	30	35	40	45
No. cans heated	150	150	150	150	150	150	150	100
No. cans swelled	150	99	73	6	1	0	0	0
Percentage swelled	100	66	49	4	0.6	0	0	0

The above table shows that when this particular organism or one equally resistant is present it will be unprofitable to process at 240° F. (115$\frac{5}{9}$° C.) for a shorter time than 30 minutes.

These cans differed from the normal only in two particulars. We made sure that they contained spores of the germ we desired to test and after the test we held them at a temperature which would encourage the growth of any germs which might be alive in the cans.

On examining the spoiled cans it was noted that those heated but 10 minutes contained a mixture of different forms while those heated for a longer period were quite uniformly free of all but this one kind. In view of these results it is hard to understand how factories can sterilize cans under any circumstances when processing but 10 minutes at 240° F.

The factory where the outbreak occurred has used 240° F. for 30 minutes through a large part of the season with no loss from swelling aside from occasional leaks.

LIMITATION OF THESE RESULTS.

It should not be forgotten that while these results and recommendations are believed to be generally applicable to what may be expected in practice they are strictly reliable only when combating this or a less resistant species. While this germ has proven to be unusually resistant to heat it is quite possible that some factory may have trouble with another germ which is even more resistant. For this reason it was thought best to study this germ and describe it in such a way that in future outbreaks we can determine whether we have to do with the same or a different germ.

EFFECT OF 240° F. ($115\frac{5}{9}$° C.) ON COMMERCIAL QUALITY.

Some difference of opinion exists regarding the effect of 240° F. upon the texture of the pea and the clearness of the liquid.

This was brought out in the replies from the canners. Twenty-nine canners report their experiences with this temperature. Eighteen have never observed bad effects, while eleven point out dangers, in different directions. One notes a tendency to scorched flavor in the smaller sizes and two speak of the bursting of the tender peas. Seven note that in the mature peas there is trouble with the liquor becoming muddy if the heating is too long continued.

The cans which had been heated at the factory to determine the death point of the gas-forming germs gave us an excellent opportunity to judge of the effect of heating for various intervals upon the quality of the product.

The Alaska peas were examined by three competent judges immediately after cooling with the following results:

(1) The liquor was good and clear but seemed slightly brown in all cases except those heated but ten minutes. The others seemed all of the same shade.

(2) The peas were darkened in all cases where heated more than ten minutes. This darkening increased in all with the length of exposure but was much more marked in the larger size (No. 4).

(3) There was a scorched taste in those heated thirty-five, forty and forty-five minutes which in the two longer intervals was sufficiently marked as to be objectionable in the market. No scorched taste was distinguishable in those heated thirty minutes or less.

(5) There was a slightly scorched smell in cans heated thirty-five minutes or longer but not enough to be objectionable.

At the end of eight months the cans heated but ten minutes had spoiled but samples of those remaining were submitted separately to eight men familiar with pea canning, three of whom were well posted as to the demands of the market. Their opinions varied but little, the better posted men being slightly more critical; and may be summed up as follows:

Alaska No. 1.—All pass without question. Color fine, liquor slightly darker in those heated thirty-five minutes and longer. Liquid not muddy in any. No scorched taste except faint trace in those heated forty and forty-five minutes.

Alaska No. 4.—Color dark in all but not muddy. Possibly due to short blanch. Those heated thirty minutes or more would be liable to complaint on color. No scorched taste.

Advancers No. 3.—All pass without question. Color good and liquor not muddy. Very faint scorched taste in those heated forty minutes.

There was a noticeable decrease in all objectionable results of the high heating during the interval between the two examinations except in the case of the color. When first examined the liquid was but slightly colored while the peas were noticeably darkened. On standing this discoloration passed from the peas out into the liquor. It is thought that by lengthening the blanching process this trouble could be largely overcome.

The decrease in the scorched flavor was especially marked. Immediately after cooking it was very noticeable in certain cases while at the later examination it was not detected at all by a number of the judges.

CONCLUSION.

Swelling of canned peas is caused by bacteria which form such resistant spores as to survive ordinary processing.

In the outbreak studied, 240° F. ($115\frac{5}{9}$° C.) for 30 minutes was found to be sufficient to destroy this germ when present in the cans in large numbers. This temperature has since been used by the factory with complete success.

Except under unusual conditions this amount of heating does not injure the commercial value of the peas.

The aim of this investigation has been to determine a safe minimum amount of heating. The amount additional, if any, which should be used in any case to produce the desired cook is a matter for the judgment of the processor and one in which he will display his mastery of his art.

VITALITY OF THE CABBAGE BLACK ROT GERM ON CABBAGE SEED.[1]

H. A. HARDING, F. C. STEWART AND M. J. PRUCHA.

SUMMARY.

Black rot of cabbage is a destructive bacterial disease caused by *Pseudomonas campestris* (Pam.) Smith. No satisfactory method of controlling the disease in the field has yet been found. Concerning the ability of the disease germs to survive the winter on the seed, there has been a difference of opinion. The present bulletin gives an account of some investigations bearing on this point.

The conclusion is that much of the cabbage seed on the market is contaminated with germs of the black rot disease and that some of these germs may survive the winter and become a source of infection to the young cabbage plants.

As a precautionary measure, it is advised that all cabbage seed be disinfected before sowing, by soaking for fifteen minutes in a 1-1000 corrosive sublimate solution or in formalin, one pound to thirty gallons. It is not expected that this treatment will prevent either leaf or root infection in infected soils; but it may be safely relied upon to prevent all danger from infected seed. It will not injure the germination.

INTRODUCTION.

Black rot in cabbage is primarily a trouble of the fibro-vascular bundles. During the progress of the disease these bundles become dark brown or black. On cutting across the petiole of a diseased leaf the affected bundles are seen as dark points. When so many of the bundles are affected as to cut off the supply of water to a leaf the blade dries up and resembles a piece of brown

[1] A preliminary note on this investigation was published in *Science*, N. S. 20: 55. July 8, 1904. A reprint of Bulletin No. 251.

parchment, the blackened veinlets standing out sharply against the brown background. As the leaves in the head become affected they decay, producing a dark, vile-smelling mass.

This trouble was brought to the attention of pathologists at the time of an epidemic when the loss in infected fields was often total and consequently an exaggerated idea of the average fatality of the disease arose. Study extended over a number of seasons has shown that the true epidemic aspect appears only under unusual combinations of several factors, prominent among which are high temperature and abundant moisture. Under usual conditions a majority of the plants in a field may be infected and yet mature a considerable crop although a smaller one than would have been otherwise produced. In the latter case the disease may pass unnoticed except by those familiar with its appearance.

The black rot of cabbage is caused by *Pseudomonas campestris* (Pam.) Smith, a species of bacterium which attacks several species of the Cruciferæ. This germ is widespread in the United States east of the Mississippi river; and in September, 1902, Prof. W. Paddock sent us a diseased cabbage from Colorado affected with what he believed to be black rot. In a letter accompanying the specimens he stated that this disease had been destructive in Colorado in 1901 and 1902. We established the correctness of his diagnosis by isolating *P. campestris* and determining its pathogenicity upon young cabbages in the greenhouse. While the presence of *P. campestris* in Europe[2] was not reported until 1899, the promptness with which this report has been confirmed by observers in England,[3] Holland,[4] Denmark,[5] Austria[6] and Switzerland[7] suggests that it is there widespread and of long standing.

[2] Harding, H. A. Die schwarze Fäulnis des Kohls und verwandter Pflanzen, eine in Europa weit verbreitete bakterielle Pflañzenkrankheit. *Cent. f. Bakt.*, etc., II. Abt., 6: 305–313. 1900.

[3] Potter, M. C. On the Brown Rot of the Swedish Turnip. *Jour. Board of Agr.*, 10: 314. 1903.

[4] van Hall, C. J. J. Twee Bacteriënziekten. *Tijdsch. over Plantenziekten*, 6: 169–177. 1900.

[5] Rostrup, E. 17. Oversight over Landbrugsplanternes Sygdomme i 1900. Sep–Abr aus *Tidsskrift for Landbrugets Planteavl*, 8: 109–128. Kjöbenhavn, 1901. [Ref. *Zeit. f. Pflanzenkr.*, 12: 293. 1902.]

[6] Hecke, Ludwig. Eine Bakteriose des Kohlrabi. *Zeitschrift für das landwirthschaftliche Versuchswesen in Oesterreich*, 1901. S. 469. [Ref. *Zeit. f. Pflanzenkr.*, 11: 273. 1901.

[7] Brenner, W. Die Schwarzfäule des Kohls. *Cent. f. Bakt.*, etc., II. Abt., 12: 275–735. 1904.

As we have noted in an earlier bulletin[8] the germs causing the disease sometimes gain an entrance through the broken roots, at the time of transplanting. This avenue of infection is most used during the early life of the plants. Later the germs commonly enter through the water pores at the margins of the leaves. Accordingly, the regular removal of the diseased leaves has been recommended by different writers as a method of prevention but we have carefully tested this method and found it to be a complete failure.[9]

Since the disease is annually the cause of considerable loss to the cabbage growers of the State it has been thought best to continue our study of the disease in the hopes of finding successful means of controlling it. This publication deals with the vitality of the disease germs in a dry condition, as well as their ability to survive upon cabbage seed, together with some suggestions as to protection against this danger.

A belief in the transmission of the disease by means of the seed has been held by many large growers and the subject has been mentioned by other writers, but so far as we can learn this is the first attempt to determine experimentally the correctness of this view. While we believe that the facts to be presented have been established in a reliable manner there are so many more related points of interest and importance which have not yet been solved that we had not intended to present the subject until the latter had been studied. However, the facts which we have determined seem to have such a practical bearing that we have presented them in this preliminary bulletin trusting to enlarge upon their relation to the whole problem in a later publication.

BLACK ROT IN FIELDS OF SEED CABBAGE.

SOURCE OF CABBAGE SEED.

At the beginning of the last century, Holland and Denmark furnished the bulk of our cabbage seed. The production at home has increased steadily and now the seed imported represents a small fraction of the total supply and that largely of the cheaper grade.

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[8] New York Agr. Exp. Sta. Bul. 232: 60–61. 1903.
[9] Loc. cit., pp. 49–62.

Considerable cabbage seed is now produced around Puget Sound, but for more than a quarter of a century Long Island has been an important source of supply. The soil and climate of portions of the island seem admirably adapted to this crop. While many market gardeners at the western end of the island produce seed in limited quantities, the commercial phase of the industry is most developed at the eastern end in the region about Cutchogue. Here, cabbage seed fields of several acres are common and cabbage seed is one of the staple crops.

METHOD OF SEED GROWING.

On Long Island, stock seed of the desired variety is grown under the immediate supervision of the large seedsmen. This is furnished to the farmers who produce the commercial seed under contract. The seed is sown so that the plants are ready to transplant early in August and do not reach maturity until cold weather. Early in November they are buried in shallow trenches to be set out again the following April. The flowers appear in May and the seed is ripe in July. It was formerly threshed by hand but a small threshing machine is now used by the larger growers.

DISEASES OF THE PLANTS.

While growing in the field the first season, the plants are subject to all of the ordinary cabbage diseases and in some seasons black rot has been so destructive as to make the crop practically a failure. While in the trenches in the winter a variable number of the plants rot. This is in small part the result of the black rot but is more largely due to soft rot caused by an entirely different organism identical with or closely related to *B. carotovorous* Jones.[10] A prominent seedsman who has been in the business extensively on the Island for over a quarter of a century estimates the annual loss, from rot, at twenty-five per ct. of the crop. In some cases the crop is a total loss.

This soft rot occurring in the trenches or appearing after the plants have been reset has been under observation for a number of years and we hope to present some of the results of our observations in a later bulletin.

BLACK ROT GERMS PASS THE WINTER IN CABBAGE PLANTS.

As has been stated, cabbages intended for raising seed the following season are placed in shallow trenches at the approach of freezing weather and covered with six to twelve inches of soil. Here they are frozen in and remain until spring.

At the time of opening the trenches in the spring we have on a number of occasions collected plants showing black bundles and taken them to the laboratory for study. From these plants by culture methods we have obtained *P. campestris,* it often being the only organism present in the darkened bundles. In order to avoid possible errors in recognizing the germ, cultures have been inoculated into healthy young cabbage and cauliflower plants with all precautions necessary to prevent contamination. After such inoculation black rot has appeared in two to three weeks. Check plants treated in the same manner except that they were punctured with a sterile needle have always remained healthy.

From this it is evident that the black rot germs are present in some of the plants at the time they are set out in the spring and that they are in condition to continue their attack upon the plants.

OBSERVATIONS IN THE FIELD.

May 26, 1899, six fields of seed cabbage just in bloom near Cutchogue were examined. In all the fields many plants showed the characteristic blackening of the fine veins of the leaves and in some cases so many of the bundles in the stem were affected as to cause the plant to wilt. Soft rot was sometimes present in the plants suffering from black rot.

Although it is possible to recognize the disease in the field with great certainty, in order to settle the matter beyond question plants were taken to the laboratory and cultures made from the blackened bundles. *P. campestris* was isolated from four such plants and the identity of the cultures was further strengthened by ioculating in each case into healthy cabbage plants. Each culture produced the characteristic black rot when thus inoculated into healthy cabbage plants while other healthy plants grown along side and treated as controls did not take the disease.

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[10] Harding, H. A. & Stewart, F. C. A Bacterial Soft Rot of Certain Cruciferous Plants and *Amorphophallus simlense.* *Science,* N. S., 16: 314–315. Aug. 22, 1902.

Accordingly the fact that *P. campestris,* the cause of black rot, was present in these seed cabbage plants at blooming time is settled beyond question. The observations of each succeeding season show that while the amount of black rot present varies considerably with different seasons the disease is never absent from any considerable area.

DISEASE GERMS ON THE SEED.

ISOLATION OF GERM FROM SEED PLANTS.

In June, 1900, we selected and marked four seed-bearing plants in the fields near Cutchogue, which were affected with black rot. When the seed was ripe the plants were collected by W. A. Fleet, inclosed separately in large paper bags and expressed to us. Each plant was threshed separately and a small portion of the seed soaked in sterile water. Cultures were made from this water and small portions of it were also injected into young healthy cabbage plants in the greenhouse with the usual precautions to prevent the entrance of germs from other souces. The amount of water which it is possible to inject into growing tissue is small and the production of disease in six out of twelve experimental plants is surprising. These results demonstrated the presence of *P. campestris* on the seed of three of the four seed plants examined.

The cultures made from the same water which was used in the direct inoculation of the young plants showed the presence of *P. campestris* in the case of three of the seed plants. That the colonies were really *P. campestris* was settled by inoculation with all necessary precaution into healthy young plants in the greenhouse. Black rot was produced by the use of pure cultures derived from the seed of these three different seed plants.

On comparing the results from these two methods of testing the infectiousness of the seed it was seen that the germs had been isolated by cultures from the seed of the plant which had failed to show results from the direct inoculation. Accordingly, we have a complete demonstration that the germs of black rot were present on the seed of all four of these diseased cabbage seed plants at the time of harvesting.

INTERPRETATION OF THESE RESULTS.

Concerning any experimental work it is always proper to consider in how far the conditions of the experiment have deviated from the normal and in how far the results represent actual conditions.

In 1900, up to the time of our visit in June, the conditions had not been favorable for an epidemic of black rot and the fields around Cutchogue were unusually free from evidence of this disease. All of the plants marked were later shipped us, indicating that there was little destruction after that date. The plants were fairly well developed in spite of the disease and undoubtedly would have been harvested under ordinary conditions. The plants themselves were, then, a normal part of the harvest except that their chance of carrying the disease was above the average of all the plants in the field.

The threshing operations differed somewhat from the normal. In the ordinary method the seed from a large number of plants is pounded out by hand until a heap of seed, pods and fine branches is accumulated, or the whole plant is run through a threshing machine which reduces the dry branches almost to chaff. In either case the slightly oily seeds are exposed to the dust from the crushed diseased bundles which are fairly sure to be present in considerable numbers.

The seed plants we examined were held until they were thoroughly dry, when they were threshed and the seed from each plant cleaned separately with the least possible breaking of branches or exposure to dust. In this particular they were exposed to less chance of contamination than is the seed from healthy plants under ordinary conditions.

After a careful study of the conditions attending the growth and harvesting of seed cabbage there can be no doubt that there is at least a small number of *P. campestris* on practically all the seed produced on Long Island.

While this is in some respects an undesirable state of affairs it should not be forgotten that it is one for which neither the grower nor the seedsman can be justly held responsible. For financial reasons most growers do reject, at the time of resetting, all plants evidently affected with black rot since they have found that such plants often fail to produce seed. However, from the nature of the disease they are not able to detect the less advanced cases nor can they prevent infection occurring during the second season.

The remedy does not lie in obtaining seed from other sources since there is every reason to believe that the other sources of seed are equally affected. It lies rather, as will be later shown (page 76), within the control of the individual purchaser.

VITALITY OF GERMS ON SEED.

Even though large numbers of *P. campestris* are attached to the seed at the time of harvest it does not necessarily follow that they will survive long enough to affect the succeeding crop.

P. campestris does not form spores and consequently is not well fitted to withstand adverse conditions for a long period. Upon the surface of the smooth, hard, cabbage seed, food is scarce; and moisture, which is so necessary to the life of the germs, is reduced to a minimum. The close dependence of *P. campestris* upon moisture is shown by its rapid destruction when exposed to dessication.

EFFECT OF DESSICATION OF *P. campestris*.

This point was previously tested by one of us (H) at the Wisconsin Station[11] by allowing a small drop of fresh bouillon culture of the organism to dry upon sterile cover slips, which were kept in darkness at room temperature.

In the limited number of tests which were made at that time the germs all died within 45 hours.

After the somewhat surprising results from our tests of the vitality of *P. campestris* upon cabbage seed, the tests upon cover glasses were repeated using the same organism which had been used to infect the seeds and carrying on the test under conditions which would be closely comparable to those to which the seeds were exposed.

The cultures used at Wisconsin had been grown in the laboratory about a year at the time of the test and the results may be open to some objections on that score. In order to be sure in the present instance that the culture was as nearly as possible in its natural condition it was first inoculated into a cabbage plant. There it produced the characteristic lesions of black rot. From these plants the culture was isolated and its purity determined.

The growth upon agar slope, two to three days old, was then rubbed up in sterile water as thoroughly as possible and the emulsion filtered through paper. This gave a faintly milky solution containing a very great number of individuals but free from lumps and large masses of germs.

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[11]Wis. Agr. Exp. Sta. Bull. 65:19. 1898.

Small drops of this liquid were transferred to sterile cover slips placed in sterile Petri dishes. These drops dried up within a few minutes leaving a film of germs upon each cover slip. The Petri dishes each containing five cover slips, were then wrapped in paper and placed in a closed drawer at a temperature of about 70° F. (21° C.).

Each day five coverslips were transferred each to a sterile Petri dish and melted agar added. At the end of several days transfers were made from the resulting colonies to sterile potato upon which *P. campestris* produces most characteristic growth. Pure cultures were also preserved for further identification.

The results of three such tests may be summarized as follows: During the first two days a large part of the germs are destroyed and by the end of the third day few survive. From the third to the tenth day an occasional germ is found alive but we have not found one alive after ten days. In many cases they were all dead on a coverslip before the end of the third day.

PLAN OF TEST ON CABBAGE SEED.

In view of the above results it seemed hardly probable that the germs on the seed would survive long enough to be a source of danger. To settle this point it was decided to infect some seed heavily and observe the length of time that the germs would survive.

In the test of April 29, 1903, a vigorous growth of *P. campestris* two days old on agar slope was covered with ten cubic centimeters of water and thoroughly stirred into the water. This emulsion was filtered through paper to remove the larger solid particles and 5 cc. of the filtrate poured over 260 cabbage seeds (var. Early Jersey Wakefield). After the seeds had soaked in the germ-impregnated water for a few minutes they were spread out to dry for about four hours. They were then thoroughly dry. Five seeds were placed in each of 52 sterile test tubes plugged with cotton. Twenty-six tubes were left in this condition while the other twenty-six were sealed by paraffining the cotton plugs. The whole 52 tubes were then put into covered pasteboard boxes and stored in a room which was kept at a temperature ranging from 60°–70° F. (16–21° C.). The object of paraffining a portion of the tubes was to prevent excessive drying. By treating the seeds in these different ways it was hoped to approximate the conditions at the outside and at the interior of commercial packages of seed held in storage.

SOURCE AND PATHOGENICITY OF CULTURE.

The culture of *P. campestris* which was used in this test was isolated in March, 1902, from a Long Island seed cabbage which had already passed the winter in the trenches.

To be certain that neither its exposure to low temperatures during the winter nor its subsequent long cultivation in the laboratory had destroyed its pathogenicity it was inoculated with proper precautions into two young healthy cabbage plants in the greenhouse, April 6, 1903. Ten days later the first signs of black rot were showing and within a few days both plants developed unmistakable evidence of this disease. The check plants remained healthy.

EXAMINATION OF THE SEED.

Tubes containing 5 seeds each were examined at intervals of about a month. One to two cc. of sterile water was added to each tube and allowed to stand over night. On the following morning the water and seeds were distributed among three lactose agar plates. From these plates the resulting colonies were removed and studied.

A detailed statement of the dates and results of the various examinations is given in the accompanying table.

TABLE I.—EXAMINATION OF TUBES CONTAINING ARTIFICIALLY INFECTED CABBAGE SEED.

DATE.	Interval.	TUBES EXAMINED.		TUBES CONTAINING *P. campestris*.	
		Paraffined.	Not paraffined.	Paraffined.	Not paraffined.
1903.	Months.	No.	No.	No.	No.
April 29*	....	....	....	....	....
June 2	1	3	3	2	2
July 1	2	3	3	1	2
August 1	3	1	1	0	0
September 4	4	3	3	1	1
October 2	5	3	3	2	3
November 7	6	3	3	3	3
December 9	7	3	3	2	2
1904.					
January 14	8½	1	1	0	0
January 28	9	1	1	0	0
February 25	10	3	3	2	3
April 4	11	2	2	1	1
Total	....	26	26	14	17

*Experiment started.

Attention should be called to the fact that in these tests we did not determine the number of germs which survived in any case but merely the fact that *P. campestris* was alive in certain tubes. A quantitative determination would have been desirable but in the nature of the case was difficult. The germs became so closely attached to the seeds in the long drying that when the seeds were placed directly into the agar the germs could not be dislodged by shaking and later produced a confused growth around the imbedded seeds. Grinding of the seeds was attempted but their texture was such that they were not reduced to sufficiently fine particles and the resulting growth was largely in clumps surrounding the fragments of seeds.

We did not think it desirable to sterilize the seeds before applying the cultures of *P. campestris* as such treatment would probably leave the surface of the seed in an abnormal condition and vitiate the experiment. Accordingly, the growths around the seeds were often a mixture in which *P. campestris* was compelled to struggle for existence and from which it must be isolated by sub-cultures. An earlier attempt to determine the vitality of *P. campestris* on cabbage seed failed because we added the seed to be tested to the agar without previous soaking.

A positive result in this experiment indicates with certainty that *P. campestris* was alive upon the seed but a negative result does not make it certain that they were all dead. On practically all of the seeds there were germs present other than *P. campestris*. In some cases these germs found the watery solution to which they were exposed some hours so satisfactory that they developed rapidly and overran the resulting cultures so completely that a recognition of *P. campestris* would have been impossible even though it had been present in moderate numbers.

PATHOGENICITY OF GERMS ISOLATED FROM CABBAGE SEED.

The ability to produce disease is a function of germs which is most readily affected by unfavorable conditions. It would not have been surprising if the *P. campestris* which had remained over winter on the dry cabbage seed were so weakened by this exposure as to be incapable of attacking the tissue of healthy cabbage plants.

Cultures of the germs which had been found on the seed at the various examinations were preserved and on March 25, 1904, the pathogenicity of a number of these cultures was tested by inoculating healthy cabbage plants. These plants were grown in the greenhouse and were inoculated with all precautions necessary to prevent the entrance of other germs. Several check plants were treated in the same way in all respects except that they were pierced with a sterile needle instead of one dipped into a bacterial culture. Two plants were inoculated with each culture and eight cultures were tested representing two tubes from the November, three tubes from the December, and three tubes from the February examination. Two cultures were from tubes which had been paraffined and six from unparaffined tubes.

April 15, the characteristic symptoms of black rot were showing in fourteen of the sixteen inoculated plants. May 7, the disease was very evident in all of the inoculated plants. In order to complete the proof that the diseased condition of the plants was really due to the germ inoculated, cultures were made from the diseased tissue in three plants representing a like number of the original eight cultures and *P. campestris* found in pure culture. The check plants which had grown beside the inoculated ones all remained healthy.

April 26, each of the two cultures obtained from the examinations of April 4, was inoculated into two young cabbage plants in the greenhouse with all necessary precautions. The plants were growing rapidly and the temperature in the greenhouse was high. May 3, the disease was showing in two of the inoculated plants and May 7, it was evident in all four of them. Cultures were made from the tissue of these plants and *P. campestris* obtained. The two control plants remained healthy. The accompanying plate (Plate I) shows one of these control plants as well as one inoculated with the culture of *P. campestris*. A number of leaves have already been destroyed with the characteristic lesions of black rot. The photograph was taken one month after the inoculation.

REPETITION OF THE TEST ON CABBAGE SEED.

Oct. 17, 1903, a second lot of cabbage seed was infected as nearly as possible in the same manner as in the first test using the same strain of *P. campestris*. In this test ten seeds were placed in each test tube.

We were unfortunate in this case in selecting cabbage seed which was infected with a resistant and rapid growing bacillus. When the examination of this seed was begun at the eighth month the abundant growth of this form covered the plates so completely that no *P. campestris* could be found. The method of examination was later changed so as to leave the seeds in the water only a few hours. With this modification we have obtained *P. campestris* at the end of 8½ and 9½ months respectively and the examination will be continued at later intervals.

SEED DISINFECTION.

From what has already been shown concerning the prevalence of black rot in the seed cabbage fields, the presence of the disease germs on the seed and their ability to remain alive there, it is seen that the commercial seed is a factor in the spread of the disease germs. A simple and effective method of destroying these germs is much to be desired.

SOAKING A SATISFACTORY METHOD.

Soaking seed potatoes, oats, wheat and barley in disinfecting solutions to free them from disease spores is common agricultural practice. When small quantities of seed are to be treated, as is the case with cabbage, soaking for a short time in a solution combines simplicity with thoroughness in a satisfactory manner.

In this work, the destruction of the disease germs without injury to the germination of the seed is the point to be attained. Furtunately *P. campestris* does not form spores and is quickly killed by weak solutions of common disinfectants, a 0.5 per cent. solution of lysol[12] destroying it in one minute. Since the time for sowing cabbage seed is about the same as that for planting potatoes we have tested the solutions of corrosive sublimate and formalin commonly used upon potatoes with regard to their effects upon the germination of cabbage seed.

EFFECT OF CORROSIVE SUBLIMATE ON GERMINATION.

It was first attempted to determine what strength of corrosive sublimate solution can be borne by cabbage seeds without injury to their germination. Three lots of seeds, one hundred seeds

[12] Wis. Agr. Exp. Sta. Bul. 65:19. 1898.

each, were placed for five minutes in corrosive sublimate solutions having a strength of 1-500, 1-1000, and 1-2000. A fourth lot of one hundred seeds was soaked in distilled water for five minutes as a control. The seeds were sown in pots in the greenhouse on April 7 and covered with soil to a depth of three-eighths of an inch. On April 17 the number of plants showing above ground was as follows: Control, 75; corrosive sublimate 1-500, 74; corrosive sublimate 1-1000, 80; corrosive sublimate 1-2000, 70. The treated seed gave seedlings as vigorous as those from the control. Apparently, there was no injury in any case.

As 1-1000 is the strength of corrosive sublimate used on seed potatoes it was next undertaken to determine the length of time that cabbage seed may be exposed to it without injury. April 22 one hundred cabbage seeds were placed in 1-1000 solutions of corrosive sublimate for periods of 15, 30 and 60 minutes. The same number of seeds were soaked one hour in distilled water. After treatment, the seeds were planted as before.

May 3 the seedlings were counted with the following result: Control, 69; corrosive sublimate 15 minutes, 73; corrosive sublimate 30 minutes, 82; corrosive sublimate 1 hour, 71. In this experiment the plants from untreated seed seemed a trifle more vigorous than those from treated seed. However, in view of the fact that the percentage of germination was not lowered in any case it seems likely that the greater vigor of the control plants was due to some other cause than the treatment.

Later, a pound of cabbage seed was soaked for fifteen minutes in 1-1000 corrosive sublimate solution apparently without injury. The seed germinated satisfactorily and the plants grew thriftily.

EFFECT OF FORMALIN ON GERMINATION.

In order to determine whether cabbage seed may be disinfected with formalin without injury to the germination the following experiment was made: Ten cubic centimeters of formalin (40 per ct. formaldehyde) was mixed with 2400 cubic centimeters of water. In this solution eight lots of cabbage seed, 100 seeds in each lot, were soaked for different lengths of time; two lots, 15 minutes; two lots, 30 minutes; two lots, one hour; two lots, two hours. Two other lots were left untreated for a check. As soon as the treated seeds were dried they were sown in boxes in the greenhouse. This was done September 23. On October 10 the plants from each lot of seed were counted. The seed treated fifteen minutes gave an average germination of 38 per ct.; 30 minutes, 32.05 per ct.; one hour, 24.5 per ct.; two hours, 14 per ct.; untreated, 34 per ct. The seedlings appeared equally vigorous in all lots except those treated for two hours. It seems likely that the two-hour treatment was somewhat injurious, but the experiment must be repeated before a positive statement to that effect can be made. The 15-minute treatment appeared to do no harm.

The strength of the formalin solution used in this experiment was the same as that generally recommended for use in treating potatoes to prevent scab, namely, one pint or pound to thirty gallons of water.

DIRECTIONS FOR SEED DISINFECTION.

Cabbage and cauliflower seed may be disinfected either with corrosive sublimate or with formalin.

If corrosive sublimate is used, the strength of the solution should be one part of corrosive sublimate to one thousand parts of water. The most convenient method of preparing this solution is to use the corrosive sublimate tablets sold by druggists for making disinfecting solutions. One tablet, costing one cent, is sufficient to make a pint of solution which is about the quantity required to treat one pound of cabbage seed. The seed should be soaked in this solution for fifteen minutes and then spread out to dry.

If formalin is used the strength of the solution should be one part of formalin (40 per ct. formaldehyde) to 240 parts of water and the seed soaked fifteen minutes.

With both corrosive sublimate and formalin the strength of solution recommended is approximately the same as is generally used in treating seed potatoes to prevent scab; namely, two and one-fourth ounces of corrosive sublimate to fifteen gallons of water or one pint of formalin in thirty gallons of water. Since the usual time of sowing cabbage seed is about the same as that for planting potatoes it may often happen that the solution required for disinfecting the cabbage seed may be taken from that prepared for treating potatoes, thus avoiding the bother of preparing a small quantity especially for the cabbage seed.

While it appears that cabbage seed is not injured by soaking for one hour in either solution, fifteen minutes is undoubtedly sufficient to accomplish the disinfection and there is no necessity for taking any risk on a longer treatment.

In using the corrosive sublimate solution it should be borne in mind that it is a strong poison; also, that it readily corrodes metal, hence should not be used in metal vessels. The formalin solution is much less poisonous and does not corrode metal.

A convenient method of treating the seed is to place it in a small bag made of any loose cloth readily penetrated by water and suspend the bag in the disinfecting solution for the required length of time. The seed should be dried without delay. If artificial heat is used in drying great care should be taken to avoid over heating as the germination may be thereby injured. Probably drying the seed in the sun should be avoided as it is believed by some seedsmen that exposure to sunlight injures the germination of cabbage seed.

THE RELATION OF INFECTION ON THE SEED TO OUTBREAKS OF BLACK ROT.

On accepting the truth of the facts here presented regarding the danger of spreading *P. campestris* by means of the seed the reader should not conclude that a treatment of the seed before planting will insure total immunity from an outbreak of black rot. Neither should the absence of an outbreak in untreated seed be taken as a proof of the absence of disease germs. The presence of *P. campestris* is absolutely necessary, but it is only one of several factors concerned in such an outbreak. In addition to the presence of the disease germ there must be an available avenue of entrance to the host plant and the host plant itself must be in a favorable condition to succumb before the outbreak will occur.

Outbreaks of black rot in the seed beds are not frequent. In our own observations we have found diseased plants there only occasionally. However, by the time the disease appears in the field the seed beds are usually destroyed and our observations on this point have been correspondingly limited. From the early history of the fields which we have seen and from the observations of large growers of cabbage it seems probable that in exceptional cases many of the plants in a seed bed are infected with *P. campestris.* In the absence of more direct observation, a discussion of the method of entrance of the germs to the plants in the seed bed has little value.

A second danger which probably is more important lies in the infection of the soil. By the act of transplanting, many of the plant roots are broken, exposing the cut ends of the fibro-vascular bundles. Some growers regularly break the ends from the tap roots when they are not accidentally removed. At this time if *P. campestris* is in the soil either of the seed bed or the field it has an opportunity to enter these broken bundles. Field observations have shown that infection through the roots is not infrequent. If the conditions are such as to favor an outbreak these root-infected plants quickly become a total loss and act as centers for spreading the disease in the field.

The disinfection of cabbage seed, like the treatment of seed potatoes, is intended to prevent the spread of the disease organisms. When such treated seed is planted or the plants set in infected soil the treatment will have little value.

It is not expected that seed disinfection will give complete protection against black rot. In many cases the benefit may be very small. But as the treatment costs nothing except a little bother, and no other remedy is known, it is certainly advisable to disinfect the seed and thereby avoid unnecessary risk.

REPORT

OF THE

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Table of Contents.

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REPORT OF THE CHEMICAL DEPARTMENT.

CHEMICAL CHANGES IN THE SOURING OF MILK AND THEIR RELATIONS TO COTTAGE CHEESE.*

L. L. Van Slyke and E. B. Hart.

SUMMARY.

1. *Purpose of the Work.*—The purpose of the work discussed in this bulletin was to learn the amounts of casein monolactate and casein dilactate that are formed in the ordinary souring of milk, and to consider the results in some of their practical applications to the manufacture, ripening and digestibility of cottage, or Dutch, cheese.

2. *Chemical Changes in Souring of Milk.*—(1) Decrease of milk-sugar. The loss of milk-sugar increased quite rapidly for 32 hours at room temperature (65° to 80° F., 18° to 27° C.), after which the change was small and in 72 to 96 hours ceased, when the maximum loss of milk-sugar was reached, 1.50 per ct., equivalent to about 28 per ct. of the sugar originally present in the milk. (2) Amount of lactic acid formed. The maximum amount of lactic acid formed was about 0.90 per ct., which is equivalent to about 62 per ct. of the milk-sugar that disappeared. (3) Coagulation of milk in relation to acid. At the temperatures used, the milk coagulated in 24 to 29½ hours, when the percentage of total acid shown by titration had reached 0.6 to 0.7. (4) Formation of casein monolactate and casein dilactate. When the milk was first visibly coagulated, 13 to 14 per ct. of the casein was in the form of monolactate and 86 to 87 per ct. was in the form of dilactate. With further increase of acid in the milk, the monolactate passes into the dilactate.

* Reprint of Bulletin No. 245.

3. *Yield and Composition of Cottage Cheese.*—(1) Yield of cheese from 20.5 pounds of milk varied from 3.56 to 4.63 pounds under the conditions tried. (2) Moisture in cheese varied from below 70 to over 80 per ct. The variation in moisture accounts largely for the variation in yield. The amount of moisture in cheese is dependent upon the temperature used in curdling the milk and in heating the curd to expel moisture and also on the length of time the curd is heated. Cottage cheese of the best texture should contain 70 to 75 per ct. of moisture. Best success was attained when milk was soured and curdled not much above 70° F. (21° C.) and the subsequent heating was not carried above 90° F. (32° C.) (3) Milk-sugar in the cheese varied from 3.28 to 4.08 per ct., which is equivalent to 10 to 16 per ct. of the sugar originally present in the milk. Of the sugar in the milk, 23 to 27 per ct. was decomposed in the souring. (4) Nitrogen in cheese is mostly in the form of casein dilactate, equivalent to 2 to 2.5 per ct. of nitrogen.

4. *Manufacture of Cottage Cheese by Direct Addition of an Artificial Acid to Milk.*—Milk was coagulated by addition of lactic acid and hydrochloric acid and the curd made into cottage cheese. Satisfactory results in every respect were secured. For example, hydrochloric acid (sp. gr. 1.20), diluted with 10 times its volume of water, was added to milk in the proportion of 8 ounces for 100 pounds of milk at 75° F. (24° C.) and stirred vigorously. The curd separated at once in flocculent form and was strained from the whey without further heating. Any absence of sour-milk flavor can be supplied by mixing with the cheese some ripened cream. Cheese made in this way contains more milk-sugar and more nitrogen than cheese made by the ordinary method of souring milk.

5. *Slight Change of Insoluble into Soluble Nitrogen Compounds in Cottage Cheese.* Cottage cheeses were made by ordinary souring method from whole milk and from pasteurized and unpasteurized skim-milk, with and without rennet, and were examined at intervals to ascertain to what extent insoluble nitrogen compounds change into soluble ones, as in the case of cheddar cheese. Such proteolytic changes as occurred in 2 to 3 weeks were insignificant.

6. *Artificial Digestion of Some Compounds of Casein and Paracasein contained in Cottage Cheese.*—According to popular belief, fresh cottage cheese is more readily digested than cheddar cheese. To test this by laboratory methods, we have subjected to pepsin digestion, without hydrochloric acid and with hydrochloric acid in varying proportions, fresh cottage and cheddar cheese, in which we had one or more of the following substances: Paracasein, paracasein monolactate in cheddar cheese, paracasein dilactate, casein monolactate, casein dilactate (cottage cheese) prepared by normal souring of milk and also by direct addition of lactic acid to milk, and casein dihydrochloride. (1) In the absence of acid, paracasein fails to be digested by pepsin, while paracasein monolactate (the chief nitrogen compound of fresh cheddar cheese), paracasein dilactate, casein monolactate and casein dilactate (cottage, or Dutch, cheese) are partially digested. Paracasein monolactate and casein monolactate, in the absence of acid, are digested more than are paracasein dilactate and casein dilactate. (2) In the presence of 0.4 per ct. of hydrochloric acid, paracasein dilactate is digested by pepsin more than is paracasein monolactate. Paracasein monolactate and dilactate and casein monolactate and dilactate and casein dihydrochloride digest more readily and completely in the presence of free hydrochloric acid than in its absence. (3) Casein dilactate and casein dihydrochloride do not differ in the rapidity and extent to which they are converted into soluble compounds by pepsin. (4) The addition of acid after the beginning of the digestion increases the amount of proteid digested, whether we use cottage cheese or cheddar cheese. (5) Cottage cheese made from whole milk digests more rapidly than that made from skim-milk, owing to the loose texture of the former. Fat in such cases does not impede digestion. (6) The rapidity of digestion is dependent in part upon the fineness of division of the material to be digested. Cottage cheese as ordinarily consumed is in a state of finer division than cheddar cheese. (7) Cottage cheese may be properly regarded as more readily digestible than new cheddar cheese for two reasons:—First, the casein dilactate, the chief constituent of cottage cheese, is more digestible by pepsin in the presence of free hydrochloric acid than is paracasein monolactate, the principal nitrogenous

constituent of cheddar cheese. Second, cottage cheese is in such a mechanical condition that it admits of easier attack by digestive agents than does new cheddar cheese.

7. *Description of methods used in the manufacture of Cottage, or Dutch, Cheese.*—Under this head are described (1) the material to use, (2) the preparation of a "starter," (3) the manufacture of cottage cheese (a) by ordinary souring of milk, (b) when a starter is used, (c) when rennet is used together with a starter, and (d) by direct addition of hydrochloric acid.

8. *Qualities of Cottage Cheese.*—Flavor and texture are chief importance in determining the commercial value of cottage cheese. The flavor should be that of mildly soured or properly ripened cream. The texture should be smooth and free from harshness.

INTRODUCTION.

In the ordinary souring of milk, two phenomena are familiar, first, the formation of acid resulting in giving to milk a sour taste and, second, the curdling or coagulation of the milk-casein. The formation of lactic acid in the souring of milk from milk-sugar by means of acid-forming organisms has been well known for years, but the character of the action causing coagulation of milk-casein has not been satisfactorily understood, though explained in various ways.

Among the explanations that have been offered to indicate what takes place when an acid precipitates milk-casein, we will call attention to two. The first explanation was offered by Scheele in 1780, who was the pioneer in the study of lactic acid. He expressed the view that the precipitate formed by treating milk with an acid is a compound produced by the union of the acid with milk-casein. In 1865 Millon and Commaille[1] carried on some experiments which led them to the same view. In 1893 Timpe[2] made a study of the souring of milk and stated that a given amount of casein unites with a definite quantity of lactic acid to form a definite compound.

The second explanation offered appears to have originated with Hammarsten. In 1843 Rochleder had made the statement that the precipitation of milk-casein by an acid did not result in form-

[1]*Compt. rend.*, 59: 301 (1865).
[2]*Arch. hyg.*, 18: 1 (1893).

ing a definite chemical compound. Owing to the variation in views expressed by different workers, Hammarsten[3] took up the question and concluded as a result of his work that there was no ground for believing that a chemical combination takes place between casein and the acid used to precipitate it. He based his statement on the fact that by rubbing for several days in a mortar with different portions of water a precipitate formed by casein with an acid, he was able to remove the acid so completely that the remaining precipitate gave no test for acid. With the more recent knowledge we have of the looser forms of chemical combination common to proteids and the tendency of such compounds to dissociate under conditions less severe than those used by Hammarsten, his work can not be regarded as settling the question in such an absolute manner as he indicates. According to Hammarsten,[4] milk-casein contains calcium phosphate in combination, and the treatment with acid removes the calcium phosphate, which results in precipitating casein. This view in somewhat modified forms has been held by Eugling,[5] Schaffer[6] and Söldner.[7]

In Bulletin No. 214 of this Station, pp. 67-71 (1902), we called attention in a preliminary way to the fact that we had isolated two different compounds formed by casein when treated with lactic acid, one of which we called casein monolactate and the other casein dilactate. Both compounds are insoluble in water. The monolactate is completely soluble at about 130° F. (55° C.) in a 5 per ct. solution of sodium choride, while the dilactate is practically insoluble. It appears that Hammarsten really prepared these compounds but did not recognize what they were or their relations to each other. He says:[8] "When we carefully precipitate a very dilute solution of casein with a very dilute acid, there is formed a loose precipitate, which dissolves completely in sodium chloride to an opalescent liquid." He adds that when too much acid is used, a precipitate is formed that is insoluble in sodium chloride solution.

[3] *Maly Jahresber. d. Thierchem.*, 7: 160 (1877).
[4] *Maly Jahresber. d. Thierchem.*, 4: 135 (1874).
[5] *Landw. Versuchs.-Stat.*, 31: 392 (1885).
[6] *Landw. Jahrb. d. Schweiz*, 1: 33 (1887).
[7] *Landw. Versuchs.-Stat.*, 35: 351 (1889).
[8] *Maly Jahresber. d. Thierchem.*, 7: 163 (1877).

We are still engaged in a more complete study of the chemical relations of acids to casein, the final results of which will be published later. By our further study we have been able to prepare these compounds under more complete control. It is our purpose in this bulletin to present the results of some work done to show the amounts of the mono- and di-compounds of casein formed in the usual souring of milk, and also to consider these results in some of their practical applications.

The manufacture of cottage, or Dutch, cheese is extensively carried on both on a large scale in connection with creameries and also on a small scale in private families. As this is a product of the souring of milk, it seemed to us desirable to make a careful study of the details of the process of making cottage cheese. We have paid attention in our work to the following points:

(1) What compound of casein, the monolactate or dilactate, is most largely present in cottage cheese?

(2) What conditions are most favorable for the production of the best cottage cheese?

(3) Can cottage cheese be made successfully by the direct addition to milk of artificial acids?

(4) Does ripening take place in cottage cheese, such as occurs in cheddar cheese?

(5) What is the digestibility of cottage cheese in comparison with cheddar cheese, as shown by artificial peptic digestion?

EXPERIMENTAL PART.

THE CHEMICAL CHANGES IN THE ORDINARY SOURING OF MILK.

We desired to study the relation existing between the disappearance of milk-sugar in the usual souring of milk and the formation of lactic acid, together with the resulting formation of casein monolactate and casein dilactate. In one set of experiments made for this purpose, we placed some fresh separator skim-milk in an Erlenmeyer flask, stoppered with a plug of cotton. This was allowed to stand at room temperature and samples were taken from this flask for examination from time to time. In the first experiment, the room temperature varied from 65°

to 75° F. (18° to 24° C.); in the second, from 70° to 80° F. (21° to 27° C.). In another set of experiments, we used 3000 cc. of pasteurized separator skim-milk, to which had been added 50 cc. of a sour-milk starter. We placed in each of 14 cotton-stoppered flasks 100 cc. of this milk and allowed one lot (3) to stand at a temperature of 60° to 70° F. (15.5° to 21° C.) and another lot (4) at a temperature of 70° to 80° F. (21° to 27° C.). In this second set of experiments, we used the contents of one flask for making an analysis at each stated period of time, no flask being opened until its contents were used. The results of these experiments are given in the table below:

TABLE I.—SHOWING CHEMICAL CHANGES IN THE SOURING OF MILK.

No. of experiment	Age of milk when analyzed.	Amount of milk-sugar in milk.	Amount of milk-sugar changed.	Amount of lactic acid in milk.	Proportion of sugar in milk changed.	Percentage of nitrogen in milk in soluble form.	Percentage of casein in form of monolactate.	Coagulated.
	Hours.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
1	Fresh.	5.15	——	——	——	——	——	
2	Fresh.	5.58	——	——	——	——	——	
3	Fresh.	5.08	——	0.187	——	——	——	
4	Fresh.	5.08	——	0.187	——	——	——	
1	8	4.53	0.62	——	12.04	——	——	
2	8	5.25	0.33	——	5.91	——	——	
3	8	4.53	0.55	0.011*	10.83	——	——	
4	8	4.32	0.76	0.081	14.96	——	——	
1	24	4.25	0.90	——	17.48	——	——	coagulated.
2	24	4.42	1.16	——	20.80	21.19	12.70	coagulated.
3	24	4.00	1.08	0.506*	21.26	——	——	coagulated.
4	24	3.79	1.29	.776*	25.40	——	——	coagulated.
3	26	3.92	1.16	0.596*	28.43	——	——	coagulated.
1	29½	3.88	1.27	——	24.66	17.44	14.43	coagulated.
1	32	3.71	1.44	——	28.00	22.61	13.18	
2	32	4.20	1.38	——	24.73	22.68	11.50	
3	32	3.86	1.22	0.740*	24.00	——	——	
4	32	3.76	1.32	0.848*	26.00	——	——	
1	48	3.70	1.45	——	28.10	22.80	10.20	
2	48	4.18	1.40	——	25.10	21.19	8.61	
3	48	3.79	1.29	0.821*	25.40	——	——	
4	48	3.76	1.32	0.848	26.00	——	——	
1	72	3.65	1.50	——	29.13	24.14	8.00	
2	72	4.13	1.45	——	26.00	21.38	8.61	
3	72	3.76	1.32	0.839*	26.00	——	——	
4	72	3.72	1.36	0.857*	26.77	——	——	
1	96	3.66	1.49	——	28.93	23.95	6.70	
2	96	4.07	1.51	——	27.06	22.87	6.00	
3	96	3.70	1.38	0.875*	27.16	——	——	
4	96	3.69	1.39	0.884*	27.36	——	——	
2	120	4.07	1.51	——	27.06	22.68	5.74	
3	120	3.62	1.46	0.893*	28.74	——	——	
4	120	3.64	1.44	0.884 *	28.35	——	——	

*Amount of lactic acid less the amount of acid in the fresh milk.

We will consider the data contained in Table I under the headings given below.

(1) *Decrease of milk-sugar.*—In all cases the loss of milk-sugar increases quite rapidly for 32 hours, after which additional change is slow and small. In 72 to 120 hours, the maximum loss is reached; in experiment No. 1, no further change of milk-sugar occurred after 72 hours; in No. 2, none after 96 hours. Of course, at temperatures somewhat higher, less time would be required for the transformation of the same amount of milk-sugar. Averaging our results, we find that about 11 per ct. of the sugar present in the milk at the start had disappeared in 8 hours; 21 per ct., in 24 hours; 25.5 per ct., in 32 hours; 26 per ct., in 48 hours; 27 per ct., in 72 hours; and 27.6 per ct. in 96 hours.

(2) *Amount of lactic acid formed.*—The maximum amount of acid, calculated as lactic acid, was about 0.90 per ct., which is equivalent to about 62 per ct. of the milk-sugar that disappeared. It is customary to represent in the following manner the reaction by which milk-sugar is converted into lactic acid:

Milk-sugar. Lactic acid.

$$C_{12} H_{22} O_{11} + H_2 O = 4 C_2 H_6 O_2.$$

According to this expression, all the milk-sugar is converted into lactic acid, weight for weight. While this equation expresses the most prominent chemical action that occurs, it certainly fails to give anything like a complete or accurate statement of the entire chemical action. In detail, our average results are as follows: In 24 hours, 40 per ct. of the milk-sugar that had disappeared formed acid, lactic largely; in 32 hours, 58.5 per ct.; in 48 hours, 64 per ct.; in 72 hours, 63.3 per ct.; in 96 hours, 63.5 per ct.; in 120 hours, 61.3 per ct.

As shown by Kayser,[8] there may be present in addition to lactic acid, as the products of the decomposition of milk-sugar by lactic-acid forming organisms, carbon dioxide gas, formic acid, acetic acid, acetone and alcohol. Mayer[9] has found that under the most favorable conditions, we may possibly be able to get as much as 83.9 parts of lactic acid from 100 parts of milk-sugar. The pres-

[8] *Ann. Past.*, 8:737 (1894).

[9] *Centralbl. Bakt.*, 12:99 (1892).

ence of alcohol, volatile fatty acids and gases among the lactic acid fermentation products has also been shown by Leichmann,[10] and acetone by Jacksch.[11] The quantity of lactic acid formed is dependent, according to Emmerling,[12] upon a variety of conditions, among which the following may be mentioned: The kind of organism; the reaction of the material, a neutral reaction being favorable; the presence or absence of air, the presence of air favoring the formation of more of the volatile acids; the conditions of nutrition, of temperature and of the presence or absence of certain substances.

According to Timpe,[13] for example, one of the lactic acid organisms mentioned by him is checked in its growth by .04 per ct. of free lactic acid. However, the growth is not checked, so long as there are substances present with which the acid can unite. We have such substances in milk. Using as a basis the figures given by Söldner,[14] the inorganic compounds in 100 grams of milk would unite with 0.3938 gram of lactic acid. Timpe found that 100 grams of milk-casein neutralize 8.415 grams of lactic acid; the milk-casein in 100 grams of milk containing 2.5 per ct. of casein would therefore neutralize 0.2104 gram of lactic acid. Thus the total amount of lactic acid neutralized by 100 grams of ordinary milk would be 0.604 per ct., and this was about the amount of acid found by him in milk that had soured in the usual way. In his experience, the maximum amount of acid is reached in about 50 hours at ordinary temperatures. Our results are somewhat higher than those of Timpe. We find as our maximum more lactic acid, which is nearly all formed in 48 to 72 hours. There will, of course, be a variation in different milks dependent upon the amount of casein and inorganic salts, other conditions being uniform. Richet[15] reports finding 1.6 per cent. of lactic acid in sour milk, but this figure appears too high and is probably due to some error in determination. Hueppe[16]

[10] *Centralbl. Bakt.*, 16:826 (1894).

[11] *Berl. Ber.*, 19:781.

[12] Die Zersetzung Stickstofffreien Organischen Substanzen durch Bakterien, p. 34.

[13] *Arch. hyg.*, 18:1 (1893).

[14] *Landw. Versuchs.-Stat.*, 35:351 (1889).

[15] *Compt. rend*, 86:550 (1878).

[16] *Mittheil a. d. Gesundh.*, 2:309 (1884).

reports finding 0.8 per ct. of lactic acid in sour milk, a figure that is quite close to the results of our work.

(3) *Relation of coagulation of milk to amount of acid.*—In the case of experiment No. 3, the milk was found completely coagulated, that is, solidfied in a mass, in 26 hours, when the amount of total acid had reached 0.783 per ct. In experiment No. 4, the time of coagulation was 24 hours and the percentage of total acid was 0.963. The milk in No. 2 had just coagulated when the acidity of the whey was determined and it had the characteristic odor of sour milk. A microscopic examination showed the presence of a precipitate, but no free acid was indicated by the calcium picrate test.[17] In the case of experiments No. 1, and No. 4 the milk coagulated in the night and our observation was made in the morning, just how long after coagulation we do not know. Under the ordinary conditions of souring, we can expect, according to these results, that milk will coagulate when the total acid reaches about 0.8 to 0.9 per ct. as indicated by titration with standard alkali and phenolphthalein as indicator. Deducting the amount of the original titration of the fresh milk, and calling the rest lactic acid, we have coagulation taking place when the lactic acid reaches 0.6 to 0.7 per ct. In producing this amount of lactic acid, about 1.3 per ct. of milk-sugar disappears, which is about 25 per ct. of the sugar originally present in the milk used.

(4) *Soluble nitrogen compounds.*—The soluble nitrogen compounds amounted to about 22 per ct. of the nitrogen in the milk. This is practically all accounted for by the milk-albumin. The constancy of the amount of soluble nitrogen also suggests that it was present mostly if not entirely, as milk-albumin.

(5) *Formation of casein monolactate and casein dilactate in milk coagulated by ordinary souring.*—When the milk was first visibly coagulated, the amount of casein in the form of monolactate was 13 to 14 per ct. of the casein in the milk and the amount of casein dilactate was 86 to 87 per ct. of the casein in the milk. As the milk grew more acid, the monolactate gradually passed into the dilactate. The minute amount of monolactate apparently present at the time the experiment was stopped is due to a slight solubility of dilactate in a 5 per ct. salt solution. When milk coagulates by souring in the usual way,

[17] Rohrer. *Archiv. f. Physiol.*, 90:368 (1902).

the casein is nearly all in the form of dilactate at the time the milk has set in a solid mass.

It was desired to determine the amount of casein monolactate in milk before the milk visibly coagulates. For studying this point, some milk was set aside one day at 5 p. m., and the next forenoon was warmed to about 104° F. (40° C.), when casein monolactate separated from the milk. In this case, 65 per ct. of the casein was in the form of monolactate, while no dilactate was present.

The method employed by us in separating casein, casein monolactate and casein dilactate, when they occur together in milk, is as follows: The milk is heated to 104° F. (40° C.) and the monolactate and dilactate separate as a precipitate. When only casein and casein monolactate are present, filtration serves to separate them. When the two lactates are present in the coagulum formed after heating, they are removed from other milk constituents by filtration and the monolactate is dissolved in a 5 per ct. solution of sodium chloride at about 130° F. (55° C.), when the two compounds are separated by filtration.

CONDITIONS OF MANUFACTURE IN RELATION TO THE YIELD AND COMPOSITION OF COTTAGE, OR DUTCH, CHEESE.

The names, cottage cheese and Dutch cheese, are applied to the product made by allowing milk to stand until it coagulates by ordinary souring, the curd being drained to allow the escape of much of the whey, after which it is salted, pressed into the form of balls, and is then ready for consumption. The souring is often hastened by adding a little sour milk or other "starter." In commercial manufacture on a large scale, a "starter" is used and also a small amount of rennet extract is added to the partially soured milk in order to hasten its coagulation and save time in the process of manufacture. Skim-milk is commonly employed in making cottage cheese. When whole milk is used, so much of the fat is lost in the whey that the process is a very wasteful one. It is good economy to use separator skim-milk and then to mix cream with the cheese when it is salted, if it is desired to have fat in the cheese. In this way, the fat can be more economically incorporated and its amount in the cheese kept under better control.

The directions commonly given for the manufacture of cottage cheese vary greatly in their details as stated by different writers, but in general there is a serious lack of specific details in the various steps of the operation. Thus, a great variation is found in the temperature employed for souring the milk and a still greater variation in that used for heating the coagulated mass in order to expel the whey. After presenting the results of our work, we will discuss the best conditions to be observed in making Dutch cheese.

We will first consider the results of work done when the coagulation occurred at different temperatures and the milk was allowed to sour by the lactic acid formed in the decomposition of the sugar in the milk. In each of the following experiments, we used 20 pounds of pasteurized separator skim-milk and added to it one-half of a pound of sour milk as a "starter." In experiments 2, 3 and 4, portions of the same milk were used. The milk was kept at temperatures varying from 40° to 80° F. (5° to 27° C.) in different experiments until fully coagulated, which required from 24 to 48 hours. After the mass of curd was cut or broken, it was heated to 85° to 90° F. (29° to 32° C.), until the whey separated well. It was then allowed to drain as long as whey continued to come from the mass, usually being suspended in a muslin bag to facilitate the draining.

Determinations of sugar were made in the milk, whey and cheese; and a record was kept of the amounts of whey and cheese. The conditions employed and the results obtained in the different experiments are given in Table II.

TABLE II.—SHOWING CONDITIONS AND RESULTS IN MANUFACTURE OF COTTAGE CHEESE.

No. of experiment.	Temperature used in coagulating milk.	Pounds of	Per ct. of moisture in cheese.	Per ct. of sugar in	Pounds of sugar in	Per ct. of nitrogen in	Pounds of nitrogen in
Milk.	Degrees F.	Milk.		Milk.	Milk.	Milk.	Milk.
1	70°-72°	20.5	———	5.78	1.19	0.59	0.12
2	40°-50°	20.5	———	5.69	1.17	0.56	0.11
3	60°	20.5	———	5.69	1.17	0.56	0.11
4	80°	20.5	———	5.69	1.17	0.56	0.11
Whey.		Whey.		Whey.	Whey.	Whey.	Whey.
1	———	15.87	———	4.54	0.72	0.13	0.02
2	———	16.31	———	4.78	0.78	0.14	0.02
3	———	16.31	———	4.47	0.73	0.13	0.02
4	———	15.31	———	4.35	0.67	0.13	0.02
Cheese.		Cheese.		Cheese.	Cheese.	Cheese.	Cheese.
1	———	3.94	75.8	4.04	0.16	2.41	0.10
2	———	3.56	70.9	3.28	0.12	2.50	0.09
3	———	3.63	71.8	3.40	0.12	2.43	0.09
4	———	4.63	83.9	4.08	0.19	2.00	0.09

Another set of experiments was planned to test particularly the influence of the temperature of coagulation and of subsequent heating upon the amount of moisture retained in the cheese; the results of this set of experiments are given in Table III.

In studying the results embodied in this table, we call attention to the following statements:—

(1) *Yield of cheese.*—The yield of cheese varied from 3.56 to 4.63 pounds for the 20.5 pounds of milk used. Stated in another way, it required 4.43 to 5.75 pounds of the milk used to make one pound of cheese. This difference in yield of cheese was largely due to the varying amounts of water retained in the curd.

(2) *Moisture in cheese.*—The moisture in the cheese varied from 70.9 to 83.9 per ct. This variation is largely dependent upon the temperature at which the milk is kept during souring and coagulating and especially upon the temperature and the length of time employed in expelling the whey from the curd.

(3) *Influence of temperature upon moisture of cheese.*—Special experiments were made for the purpose of studying the influence of the temperature of souring and of subsequent heating upon the amount of moisture held in the cheese. In every case we used 20 pounds of milk and one-half pound of starter. The results of this work are given in the following table:

TABLE III.—SHOWING INFLUENCE OF TEMPERATURE OF COAGULATION AND HEATING UPON MOISTURE IN CHEESE.

No. of experiment.	Temperature at which milk was coagulated.	Temperature to which mass was heated to separate whey from curd.	Time used to raise temperature to highest point used.	Time after reaching highest temperature to removing curd from whey.	Time required for curd to drain fully.	Amount of moisture in cheese.	Texture of cheese.
	Degrees F.	Degrees F.	Minutes.	Minutes.	Minutes.	Per ct.	
1	60	80	60	15	135	77.6	Good.
2	60	90	20	5	145	78.8	Soft.
3	70	80	30	30	150	81.5	Mushy.
4	70	90	40	15	10	73.5	Good.
5	80	90	20	10	60	74.9	Good.
6	80	100	35	5	50	71.8	Slightly dry.
7	90	100	20	0	5	71.5	Slightly dry.
8	90	110	30	0	5	68.1	Tough, hard.

The data in this table indicate that—(a) when the milk during souring is kept below 80° F. (27° C.) and not heated above this temperature after coagulation, the subsequent draining of the whey from the cheese is slow and incomplete and the cheese is apt to contain too much moisture (experiments 1 and 3) ; (b) when a temperature of 90° F. (32° C.) is employed after coagulation and the mass kept at this temperature for about 15 minutes, the subsequent draining of the whey from the curd is complete in a short time (experiments 4 and 5) ; (c) when a temperature of 80° F. to 90° F. (27° to 32° C.) is used during the souring and the subsequent heating carried on at or above 90° F. (32° C.) the rapidity of draining and the dryness of the curd depend upon the length of time the mass is kept at the higher temperature (experiments 5, 6, 7 and 8).

Thus, it is seen that between 60° F. and 90° F. (15.5° and 32° C.) the temperature at which the milk sours and coagulates has less influence upon the rapidity of draining and the dryness of the cheese than has the temperature and time employed in heating the mass after coagulation. The lower the temperature used in souring and coagulating the milk, the slower will the whey drain from the curd, when the degree of temperature and length of time employed in heating the mass after coagulation are the same. The higher the temperature employed in heating the mass after coagulation, the shorter is the time required to effect the separation of the whey from the curd. The longer or higher the mass is heated after the coagulation, the more quickly will the whey drain from the curd. When the curd was heated to 100° F. (38° C.) or more after coagulating at 90° F. (32° C.) the separation was completely effected by the time the higher temperature was reached and it was at once ready to drain, this process requiring only 5 minutes.

According to our experience, good results are obtained by allowing the milk to sour and coagulate at 70° F. to 75° F. (21° to 24° C.) then heating to 90° F. (32° C.) using 30 to 40 minutes to raise the temperature, the heating at 90° F. (32° C.) being continued for about 15 minutes after this temperature has been reached. If one uses a temperature above 90° F. (32° C.), say 100° F. (38° C.) the curd should be removed from the whey either at once or within a few minutes after 100° F. (38° C.) has been reached, unless it is desired to make a cheese containing less moisture. By regulating the temperature and length of time used in heating the curdled mass, one can control the moisture in the cheese, making it more or less dry at will.

When the souring of milk takes place at a temperature above 90° F. (32° C.) the curd formed is apt to be very soft and mushy, probably due to some kind of proteolytic action on casein, and it is often extremely difficult under such conditions to expel the moisture, except at a temperature that spoils the product.

The amount of moisture retained in cottage cheese is a matter of much importance in relation to the quality of the cheese. In our experience, cottage cheese should contain about 70 to 75 per ct. of moisture in order to have the much-desired smooth consistency or texture that characterizes a well-made cottage cheese. If it contains much more moisture than this, the cheese is soft, mushy, uninviting in appearance and difficult to handle. On the other hand, if cottage cheese contains only 50 or 60 per ct. of moisture, it is dry, granular and harsh and in the mouth feels like wet sawdust. It is probable that tastes may vary in respect to the amount of moisture desired. People who have never eaten anything but cottage cheese of texture like sawdust may have acquired a taste for that kind, but most people would not by preference choose such in place of that having the softer, smoother texture.

The right amount of mositure is most easily secured when the milk is kept not much above 70° F. (21° C.) in the process of souring and the subsequent heating is not carried above 90° F. (32° C.).

(4) *Amount of milk-sugar.*—The amount of milk-sugar decomposed in the souring varied from 1.23 to 1.42 per ct., which is equivalent to 22 to 25 per ct. of the sugar present in the milk. The amount of milk sugar in cheese varied from 3.28 to 4.08 per ct. Of the amount of milk-sugar present in the milk, from 57.12 to 66.90 per ct. went into the whey, while from 10 to 16.21 per ct. went into the cheese. The higher the moisture in the cheese, the greater was the amount of sugar.

(5) *Amount of nitrogen.*—The nitrogen in Dutch cheese is mostly in the form of casein dilactate. A little albumin is retained in the whey of the cheese. The nitrogen in the cheese

varied from 2 to 2.5 per ct. From 17 to 19 per ct. of the nitrogen of the milk went into the whey. Some casein dilactate in the form of fine particles of curd, is usually lost in the operation of removing the whey from the curd.

(6) *Separation of whey from curd.*—It is a matter of importance in the manufacture of cottage cheese that the whey shall separate readily from the curd and shall be clear. Milky whey means loss of solids and usually accompanies a slow separation of whey. For effecting satisfactorily the separation of whey from curd, milk is generally heated to a temperature considerably above that employed in souring the milk. In our experience, we have found the whey to separate readily and clear when the souring has been carried on at a temperature of about 70° F. (21° C.) and after complete coagulation and cutting, the temperature has been gradually raised to 85° to 90° F. (29° to 32° C.), and held at that temperature for not less than fifteen minutes.

THE MANUFACTURE OF COTTAGE CHEESE BY THE DIRECT ADDITION OF AN ARTIFICIAL ACID TO MILK.

Since the coagulation of milk-casein can be readily accomplished by adding any common acid directly to milk, it occurred to us that some practical application could be made of this fact in the preparation of cottage cheese. We first used lactic acid, adding it to milk in the proportions of 0.4, 0.5, 0.6, 0.8 and 1 per ct. by weight of the milk used. Hydrochloric acid was also used in proportion of 0.25 per ct. The acid was always diluted with 8 to 10 times its volume of water before being added to the milk. The procedure was to bring the milk to a certain temperature and then to add the diluted acid to the milk, mixing it through the mass of milk as quickly and completely as possible. The mixing not only distributes the acid but prevents the curd forming in a solid mass or in large lumps. The stirring is continued until the whey separates clear. The curd separates in flocculent form and does not need any additional cutting or breaking. When small quantities of milk are used, the whole mass can be put on a strainer and allowed to drain. In the case of large quantities of milk, the curd can be allowed to settle in the vat and the whey run off in the usual way and the curd allowed to drain. In the experiments tabulated below, we used in each case 20 pounds of pasteurized separator skim-milk. After the addition of acid, the curd was allowed, in several cases, to stand 15 to 45 minutes before removing the curd from the whey, but usually there was no advantage in waiting this length of time.

TABLE IV.—MANUFACTURE OF COTTAGE CHEESE BY USE OF ARTIFICIAL ACIDS.

No. of experiment.	Temp. of milk when acid was added.	Kind and amount of acid used.	Character of curd.	Character of whey.	Moisture in cheese.
	Degrees F.	Lactic.			Per ct.
1	90°	0.4 per ct.	Soft and slimy	Sep., slow	
2	90°	0.5 per ct.	Softer than 3	Clear	70.9
3	90°	0.6 per ct.	Firm and dry	Clear	64.7
4	75°	0.6 per ct.	Good	Clear	74.6
5	105°	0.6 per ct.	Hard, dry	Clear	60.4
6	105°	0.8 per ct.	Tough, dry	Clear	62.0
7	105°	1.0 per ct.	Tough, dry	Clear, sour	51.8
		Hydrochloric.			
8	75°	0.25 per ct.	Good	Clear	73.1
9	75°	0.25 per ct.	Good	Clear	76.4

The following statements summarize the data embodied in Table IV:—

(1) *Amount of acid used.*—When less than 0.5 per ct. of lactic acid was used, the resulting curd was soft and slimy, and the whey separated slowly and incompletely. When more than 0.6 per ct. of lactic acid was used, the curd was too dry. The use of 0.25 per ct. of hydrochloric acid gave satisfactory results. We have previously[18] called attention to the fact that mineral acids are required in smaller amounts than organic acids to precipitate casein completely.

(2) *Effect of temperature.*—When the milk was at a temperature of 105° F. (40° C.) at the time the acid was added, the whey was clear and separated rapidly, but the curd was much too dry and hard. Good results were obtained at 90° F. (32° C.), when we used 0.5 per ct. of lactic acid, while with 0.6 per ct. the curd was too dry. The temperature of 75° F. (24° C.), with 0.6 per ct. of lactic acid gave good results in every respect. With 0.25 per ct. of hydrochloric acid, a temperature of 75° F. (24° C.)

[18]Bulletin No. 14, p. 67, (1902).

gave a very satisfactory product in respect to clearness of whey, rapidity of its separation and texture of curd.

Three special experiments were made to test the action of different temperatures upon the coagulation of milk-casein by hydrochloric acid. In each of these experiments we used 20 pounds of separator skim-milk and added 0.25 per ct. of hydrochloric acid. The results are given in the following table:—

TABLE V.—SHOWING INFLUENCE OF TEMPERATURE ON COAGULATION OF CASEIN BY HYDROCHLORIC ACID.

No. of experiment.	Amount of milk used.	Amount of hydrochloric acid used.	Temperature of milk when acid was added.	Length of time required for curd to drain.		Yield of cheese.	Moisture in cheese.
	Pounds.	Per ct.	Degrees F.	Hours.	Min.	Pounds.	Per ct.
1	20	0.25	60°	20	—	2.9	72.4
2	20	0.25	70°	1	—	3.9	73.1
3	20	0.25	80°	—	30	3.85	72.1

The data embodied in Table V show that—(a) there was little difference in the yield of cheese or moisture in the cheese when the milk was at different temperatures at the time the acid was added; (b) the time required for the curd to drain free from whey was greatest when the lowest temperature was used, decreasing with increase of temperature. From these figures, it appears that good results may be obtained at any temperature between 70° F. and 80° F. (21° C. and 27° C.).

COMPARISON OF RESULTS OF MAKING COTTAGE CHEESE BY DIFFERENT METHODS.

In the following table we present the summarized results of work done by us in making cottage cheese (1) by natural souring of milk with and without the addition of a starter, (2) by coagulating milk with starter and rennet, (3) by direct addition of lactic acid, and (4) by direct addition of hydrochloric acid. The same milk was used in experiments 2, 3, 4 and 5.

Table VI.—Showing Results of Making Cottage Cheese by Different Methods.

No. of experi-ment.	Casein coagu-lated by	Per ct. of acid in	Pounds of	Per ct. of water in	Per ct. of sugar in	Pounds of sugar in	Per ct. of nitro-gen in	Pounds of nitro-gen in
	Milk.	Milk.	Milk.		Milk.	Milk.	Milk.	Milk.
1	Natural souring	———	20		5.69	1.17	0.56	0.110
2	Natural souring	0.20	20		5.28	1.06	0.67	0.134
3	Starter	0.20	20.5		5.28	1.08	0.67	0.137
4	Starter and rennet	0.20	20.5		5.28	1.08	0.67	0.137
5	Hydrochloric acid	0.30	20		5.28	1.06	0.67	0.134
6	Hydrochloric acid	0.25	20		5.22	1.04	0.58	0.12
7	Lactic acid	0.60	20		5.22	1.04	0.58	0.12
	Whey.	Whey.	Whey.		Whey.	Whey.	Whey.	Whey.
1	Natural souring	0.65	16.3		4.62	0.75	0.130	0.020
2	Natural souring	0.72	15.5		4.10	0.64	0.143	0.022
3	Starter	0.72	15.9		4.10	0.65	0.151	0.024
4	Starter and rennet	0.70	15.7		3.97	0.62	0.131	0.021
5	Hydrochloric acid	0.49	16.5		5.24	0.86	0.125	0.021
6	Hydrochloric acid	———	16.2		5.08	0.82	0.09	0.014
7	Lactic acid	0.60	16.5		5.09	0.84	0.09	0.014
	Cheese.	Cheese.	Cheese.	Cheese.	Cheese.	Cheese.	Cheese.	Cheese.
1	Natural souring	———	3.60	71.3	3.35	0.12	2.48	0.090
2	Natural souring	6.48	4.40	77.6	3.91	0.17	2.40	0.106
3	Starter	7.20	4.00	72.8	3.37	0.13	2.60	0.104
4	Starter and rennet	7.56	4.20	75.6	3.64	0.15	2.52	0.106
5	Hydrochloric acid	3.78	3.90	72.6	3.90	0.15	2.87	0.112
6	Hydrochloric acid	———	3.75	76.4	4.64	0.17	2.70	0.100
7	Lactic acid	———	3.50	74.6	4.72	0.17	2.94	0.100

(1) *Yield of cheese.*—The yield of cheese did not vary greatly in the different processes of manufacture. From the same kind of milk, we should obtain about the same amount of water-free cheese. The difference of moisture makes most of the difference in yield and this can be regulated by the temperatures employed, other conditions being uniform.

(2) *Composition of cheese.*—The cheese made by acids contains a little more milk-sugar than that made by the natural souring of milk. This is due to the fact that in the process of natural souring, the fermentation changes about one-fourth of the milk-sugar into lactic acid and other compounds, while no such change occurs in the direct use of acids.

The cheese made with acids also contains a little higher amount of nitrogen, indicating a somewhat more complete recovery, in the cheese, of the nitrogen of the milk.

(3) *Advantages of using an artificial acid directly in making cottage cheese.*—The following advantages may be mentioned in favor of making cottage cheese by direct addition of an artificial acid to milk:

First, there is a marked saving of time and labor.—When milk is soured in the usual way, it is necessary to wait 24 to 48 hours and, even when a starter and rennet are used, not much less than 24 hours is required. In the use of acid, the curd separates at once. In the usual method of coagulation, the curd has to be cut or broken up, while in the direct use of an acid the curd is made to separate at once in flakes by stirring. From the beginning of the operation to the removal of the whey, only a few minutes are required by using artificial acid, while by natural souring the same stage is reached only after 24 to 48 hours.

Second, ordinary room temperature can be used.—In our experience, a temperature of 70° F. to 80° F. (21° C. to 27° C.) gives entirely satisfactory results. In normal souring, a considerably higher temperature is required after souring and coagulation to make the whey separate rapidly and at the same time clear and to put the curd into condition to drain readily.

(4) *Objections to the use of artificial acids in making cottage cheese.*—The following objections may be suggested against the direct use of artificial acids in making cottage cheese:

First, cottage cheese made from sweet milk by the direct addition of an artificial acid does not have the characteristic flavor of cheese made from milk that sours in the usual way. This objection may easily be met since the flavor may readily be secured by mixing with the cheese some sour milk, or preferably, cream.

Second, the cost of acid adds to the cost of the process of manufacture. To make 100 pounds of milk into cottage cheese would require 8 to 10 fluid ounces of hydrochloric acid. This amount of milk would make about 18 pounds of cheese; and the acid required would cost between 4 and 5 cents, or at the rate of about one-quarter of a cent for each pound of cheese. When the saving of time and of heat is taken into consideration, it is readily seen that the small additional cost is more than balanced.

CHANGE OF INSOLUBLE INTO SOLUBLE NITROGEN COMPOUNDS IN COTTAGE CHEESE.

In Bulletins 234 and 236 of this station, we have shown to what extent the insoluble nitrogen compounds of new cheddar cheese change into soluble forms during the process of ripening. While Dutch cheese is made to be eaten fresh or within a few days after its preparation, and is not expected to undergo a period of ripening like cheddar cheese, we desired to learn to what extent such digestive changes might occur in cottage cheese. For this purpose, seven lots of cottage cheese were made under different conditions. In every case we used 30 pounds of milk and, except in experiment 1, one-half pound of sour-milk starter. The samples of cheese were all kept in an atmosphere of chloroform to prevent the action of organisms, and at a temperature of 60° F. (15.5° C.). The milk used was separator skim-milk, pasteurized in experiments 2 and 6 and unpasteurized in experiments 3 and 7, and whole milk in experiments 1, 4 and 5. In experiment 1, the milk, 2 hours old, was coagulated by 0.4 per ct. of lactic acid in the presence of 3 per ct. of chloroform. In experiments 2, 3 and 4, the milk was allowed to sour naturally at room temperature except that a starter was added, while in experiments 5, 6 and 7, 0.5 cc. of Hansen's rennet extract was used in addition to the starter 8 hours after the starter was added. When rennet was used the milk was allowed to stand 48 hours, after which the temperature was raised to about 100° F. (38° C.) for 15 minutes in order to cause separation of whey. From the results of some of our work, it appears that milk to which rennet has been added appears to form acid less rapidly. Hence, it is well to let the formation of acid get well started before adding rennet. This can be done by waiting about 8 hours before adding rennet.

The special conditions used in preparing the different lots of cheese are stated in tabular form as follows:

TABLE VII.—SHOWING CONDITIONS USED IN PREPARING CHEESE FOR PROTEOLYTIC STUDY.

No. of experiment.	KIND OF MILK USED	Amount of starter used.	Amount of rennet extract used.	Temp. of milk while souring.	Temp. at which whey separated from curd.	Water in cheese.
		Pounds.	Cc.	Deg. F.	Deg. F.	Per ct.
1	Whole. Not pasteurized...	0.	0.	75	———	71.07
2	Skim. Pasteurized........	0.5	0.	75	90°	81.40
3	Skim. Not pasteurized....	0.5	0.	75	90°	78.60
4	Whole. Not pasteurized...	0.5	0.	75	104°	75.40
5	Whole. Not pasteurized...	0.5	0.5	75	106°	74.20
6	Skim. Pasteurized........	0.5	0.5	75	98°	72.05
7	Skim. Not pasteurized....	0.5	0.5	75	98°	68.00

The following table gives the results of analyses of these cheeses at different intervals:

TABLE VIII.—SHOWING RESULTS OF PROTEOLYTIC CHANGES IN COTTAGE CHEESE.

No. of experiment.	Age of cheese when analyzed.	Total nitrogen in cheese.	PERCENTAGE OF NITROGEN IN CHEESE EXPRESSED IN FORM OF					Milk-sugar in cheese.
			Casein monolactate.	Water-soluble nitrogen.	Paranuclein, caseoses and peptones.	Amide compounds.	Ammonia compounds.	
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	Fresh	2.08	11.54	3.17	0.77	2.40	0	3.74
1	4 days	2.01	8.96	3.28	1.30	2.00	0	3.80
1	10 days	1.99	10.05	3.52	0.00	0.00	0	3.72
1	15 days	2.07	9.18	3.00	2.03	0.97	0	3.72
1	18 days	1.98	9.60	3.03	2.02	1.01	0	3.68
1	21 days	2.08	9.62	2.89	0.00	2.89	0	3.68
2	Fresh	1.88	2.66	3.40	1.28	2.13	0	2.72
2	5 days	1.90	2.11	5.26	0.53	4.74	0	2.90
2	8 days	1.92	5.21	5.73	1.04	4.69	0	2.92
2	14 days	1.90	3.16	5.79	1.05	4.74	0	2.88
3	Fresh	2.21	4.53	4.53	1.81	2.72	0	2.60
3	5 days	2.25	2.22	5.33	3.12	2.22	0	2.64
3	8 days	2.14	2.80	5.60	1.87	3.74	0	2.68
3	14 days	2.18	2.75	6.88	2.75	4.13	0	2.72
4	Fresh	2.22	2.25	4.96	0.00	0.00	0	3.32
4	5 days	2.34	2.14	5.98	3.42	2.56	0	3.36
4	8 days	2.33	1.72	5.58	1.72	3.86	0	3.32
4	14 days	2.40	2.08	5.83	2.08	3.75	0	3.32
5	Fresh	1.98	2.02	5.05	3.03	2.02	0	3.48
5	3 days	2.10	2.38	5.72	2.86	2.86	0	3.22
5	7 days	2.05	1.95	6.34	2.93	3.41	0	3.08
5	10 days	1.98	2.53	7.58	4.04	3.54	0	3.00
5	14 days	1.90	2.64	7.90	3.26	2.64	0	2.84
5	17 days	1.92	2.60	8.33	5.73	2.60	0	2.80
5	21 days	1.98	3.03	8.08	5.56	2.52	0	2.80
6	Fresh	3.34	2.69	3.29	1.80	1.49	0	2.80
6	3 days	3.49	2.29	4.01	2.58	1.43	0	2.76
6	7 days	3.56	2.53	4.21	2.25	1.96	0	2.68
6	10 days	3.29	2.12	4.86	2.74	2.12	0	2.68
6	14 days	3.28	2.44	4.57	3.05	1.52	0	2.60
6	17 days	3.35	2.39	5.08	3.28	1.80	0	2.60
6	21 days	3.22	1.24	5.28	3.42	1.86	0	2.64
7	Fresh	3.26	2.15	4.91	3.37	1.54	0	2.39
7	4 days	3.44	2.33	4.94	3.49	1.45	0	2.32
7	7 days	3.27	2.45	5.50	3.06	2.44	0	2.36
7	11 days	3.35	1.79	5.37	2.99	2.38	0	2.24
7	14 days	3.36	2.08	5.95	4.47	1.48	0	2.20
7	18 days	3.42	2.92	7.02	4.97	2.05	0	2.38

A careful study of the results embodied in Table VIII indicates that the increase of soluble nitrogen compounds was very slight. In experiments 1 to 4, the only proteolytic enzymes were those present in the milk, while in experiments 5 to 7 we had rennet-enzyme in addition. The only case in which the rennet appeared to have any influence at all was in experiment 5 as compared with 4, and the actual difference here was small. In the case of the cheese made from unpasteurized skim-milk, experiments 3 and 7, we have a little more soluble nitrogen than in cheeses 2 and 6, which were made from pasteurized skim-milk. There was little or no change in the amount of milk-sugar except in the case of experiment 5. Taking all our data into consideration, we are unable to see any marked evidence of proteolytic change. These results are not unexpected, since we should hardly expect to find just such changes occurring in cottage cheese as occur in cheddar cheese, because in one case our proteid is paracasein monolactate and in the other paracasein dilactate and the reaction is practically neutral in one case and decidedly acid in the other.

STUDY OF ARTIFICIAL DIGESTION OF SOME COMPOUNDS OF CASEIN AND PARACASEIN CONTAINED IN COTTAGE CHEESE.

There is a popular belief, which appears to have some foundation in experience, to the effect that fresh cottage cheese is more readily digestible than cheddar cheese, especially new cheddar cheese. It seemed desirable to ascertain by artificial digestion to what extent laboratory experiments are in harmony with this popular belief. We have worked with the following materials: Paracasein, paracasein monolactate of cheddar cheese, paracasein dilactate, casein monolactate, casein dilactate (cottage cheese) prepared by normal souring of milk and by direct addition of lactic acid to milk, and casein dihydrochloride. These materials have been treated with varying amounts of pepsin, with and without hydrochloric acid. Experiments were also made to study the influence of the fineness of the materials upon the rate of digestion.

(1) *Comparison of digestibility of paracasein and paracasein monolactate without acid.*—The paracasein used in this experiment was prepared by coagulating fresh milk with rennet-extract and was carefully washed. Freshly prepared cheddar cheese, in which over 75 per ct. of the nitrogen existed as paracasein monolactate, was used as the source of this monolactate. The samples (25 grams) were ground with sand and in each of several bottles there was placed material equivalent to 0.694 gram

of nitrogen with 80 cc. of water. The bottles and contents were heated to 212° F. (100° C.) for 15 minutes to destroy all enzymes and organisms. After cooling, there were added to each bottle 3 cc. of chloroform and 20 cc. of pepsin solution containing 0.150 gram of Parke Davis & Co.'s aseptic scale pepsin. The bottles were kept at 98° F. (37° C.) and examined at intervals. Enough bottles were prepared in each case so that one bottle was used for each examination, no bottle being opened until analyzed. The analytical results are given in the accompanying table:

TABLE IX.—SHOWING DIGESTION OF PARACASEIN AND PARACASEIN MONOLACTATE BY PEPSIN WITHOUT FREE ACID.

Material containing	Nitrogen in material.	Nitrogen in form of paracasein monolactate.	Nitrogen in material in soluble form.	Percentage of Nitrogen in Material Expressed in Form of Water-Soluble nitrogen.				
				In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Paracasein........	4.11		2.43	6.62	6.62	7.06	7.64	6.62
Paracasein monolactate....	3.52	75.27	3.98	17.00	22.62	22.91	40.78	45.96

These results show that the paracasein failed to digest, while the paracasein monolactate digested quite rapidly, when we consider the absence of free acid.

(2) *Comparison of digestibility of casein monolactate and casein dilactate without acid.*—The casein monolactate was prepared by treating 20 pounds of milk with 32.6 grams of lactic acid. On heating at 98° to 104° F. (37° to 40° C.) the monosalt separated as a characteristic rubber-like mass. A portion of it on testing was found to dissolve completely in a 5 per ct. solution of sodium chloride. The casein dilactate was prepared by allowing milk to sour in the usual way for making Dutch cheese. These materials, carefully washed, were prepared for digestion as described under (1) preceding, except that in each bottle we used 0.200 gram of pepsin in place of 0.150 gram and one per ct. of chloroform instead of three per ct. The amount of nitrogen in each bottle was 0.830 gram. No acid was added to the contents of the bottles. The results are tabulated below:

TABLE X.—SHOWING DIGESTION OF CASEIN MONOLACTATE AND CASEIN DILACTATE BY PEPSIN WITHOUT ACID.

MATERIAL.	Nitrogen in material.	Total nitrogen in each bottle.	PERCENTAGE OF NITROGEN IN MATERIAL, EXPRESSED IN FORM OF WATER-SOLUBLE NITROGEN.				
			In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Per ct.	Gram.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Casein dilactate	2.34	0.830	8.56	11.81	21.69	22.65	23.37
Casein monolactate..	4.15	0.830	14.34	16.51	23.61	26.63	29.64

The casein monolactate digested in the absence of free acid somewhat more rapidly than the dilactate. This result we did not anticipate, since it was expected that the compound containing the higher amount of acid would be acted upon more quickly by pepsin. It may be suggested, in explanation of this behavior, that the acid in the dilactate appears to be in more stable combination than in the monolactate.

(3) *Comparison of the digestibility of paracasein monolactate and paracasein dilactate with and without acid.*—The paracasein dilactate was prepared by allowing 20 pounds of milk and half a pound of sour-milk starter to stand eight hours at room temperature and then adding 0.5 cc. of rennet-extract, after which it was allowed to remain until quite acid. The monolactate was obtained in the form of new cheddar cheese, in which 66.21 per ct. of the nitrogen was in the form of monolactate. These materials were prepared for digestion as described under (1) preceding, except that we used 0.300 gram of pepsin, and 1 cc. of chloroform, and in experiments 3 and 4 we used in addition 0.4 per ct. of hydrochloric acid.

TABLE XI.—SHOWING DIGESTION OF PARACASEIN MONOLACTATE AND DILACTATE WITH AND WITHOUT ACID.

MATERIAL.	Hydrochloric acid used in digestion.	Total nitrogen in each bottle.	PERCENTAGE OF NITROGEN IN MATERIAL, EXPRESSED IN FORM OF WATER-SOLUBLE NITROGEN.				
			In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Per ct.	Gram.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1. Paracasein monolactate	0.	0.710	23.66	27.46	49.72	51.84	62.11
2. Paracasein dilactate.............	0	0.710	14.23	14.51	24.37	31.83	33.52
3. Paracasein monolactate	0.4	0.710	48.31	56.63	46.77	51.56	57.33
4. Paracasein dilactate.............	0.4	0.710	67.75	73.35	70.43	67.89	73.39

In studying the data embodied in Table XI, we notice the same fact to which attention has already been called, viz.: that, in the absence of free acid, the monolactate undergoes pepsin digestion more rapidly than the dilactate. When, however, free acid is present, the reverse is true, the dilactate digesting more rapidly than the monolactate. The initial activity of digestion is considerably greater in both cases in the presence of acid. The following explanation is suggested to show why, in the presence of free acid, the dilactate digests more rapidly. The monolactate is first converted into dilactate and thus uses some of the acid, so that less acid is left free to take part in the pepsin digestion.

(4) *Comparison of digestibility of casein dilactate and casein dihydrochloride with and without acid.*—The casein dilactate and dihydrochloride were prepared by treating milk with 0.6 per cent. of lactic acid and 0.2 per cent. of hydrochloric acid. The resulting products were washed and prepared for digestion as described in (1) and (3) preceding, except that the materials were not ground with sand and were not heated. In 1 and 2 no free acid was added to the digestion bottles, while in 3 and 4 we used 0.4 per ct. of hydrochloric acid.

TABLE XII.—SHOWING DIGESTION OF CASEIN DIHYDROCHLORIDE WITH AND WITHOUT ACID.

MATERIAL.	Hyrochloric acid used in digestion.	Total nitrogen in each bottle.	PERCENTAGE OF NITROGEN IN MATERIAL, EXPRESSED IN FORM OF WATER-SOLUBLE NITROGEN.				
			In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Per. ct.	Gram.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1. Casein dilactate........	0	0.730	11.37	17.95	34.25	42.47	49.05
2. Casein dihydrochloride..	0	0.730	11.65	15.07	31.51	43.42	50.69
3. Casein dilactate........	0.4	0.730	84.94	84.53	96.58	96.04	96.50
4. Casein dihydrochloride..	0.4	0.730	83.56	85.90	92.20	94.94	97.27

The data in Table XII show no essential difference in digestibility between the casein dilactate and casein dihydrochloride. This is true both in the absence and presence of free acid. Increased digestion is caused by free acid. The most marked increase being in the first period (4 hours) of digestion.

(5) *Comparison of digestibility of cottage cheese made from whole milk and from skim-milk.*—We desired to test the influence

of fat in cottage cheese upon its digestibility. The cheese was prepared in each case by adding 0.2 per ct. of hydrochloric acid to the milk used. We thus had casein dihydrochloride as our protein, containing, in one case, 12.65 per ct. of fat and, in the other, 0.62 per ct. The materials were prepared for digestion as described in (4) preceding. In the case of the whole milk about 40 per ct. of the fat was lost in the whey.

Table XIII.—Showing Digestion of Cottage Cheese Made From Whole Milk and Skim Milk.

Cheese made from	Fat in cheese.	Hydrochloric acid used in digestion.	Percentage of Nitrogen in Material, Expressed in Form of Water-Soluble Nitrogen.				
			In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Per. ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Whole milk..............	12.65	0.4	80.97	87.02	88.23	93.26	93.95
Skim-milk...............	0.62	0.4	68.00	80.28	89.97	93.09	92.91

The results in this table indicate that the cheese made from whole milk digested more quickly than the cheese made from skim-milk. This could not be accounted for by saying that the whole milk contained more proteolytic enzyme than the skim-milk, because milk-enzymes, even when present in different quantities, do not appear to have the power of producing such differences in so short a time. The true explanation probably lies in the fact that the whole-milk cheese was much more porous and loose in texture, owing to the presence of the fat, and so offered a better mechanical condition for the action of the digestive agent. The fat in this case not only did not impede digestion, but indirectly favored it.

(6) *Influence of mechanical division upon the digestion of cheese.*—The mechanical condition or fineness of division of food is known to have a marked influence upon digestion. In testing this point, we prepared fresh cheddar cheese and fresh cottage cheese. The cheddar cheese contained 70.4 per ct. of its nitrogen as paracasein monolactate. All the bottles contained the same contents of water and 0.4 per ct. of hydrochloric acid. In experiment 1 the cottage cheese was made as fine as possible by grinding with quartz sand, while in 2 the cheese was in the condition in which it is ordinarily consumed. In experiment 3, the

cheddar cheese was ground with sand, in 4 it was chopped about as fine as would be made by ordinary chewing, and in 5 it was cut into cubes about one-quarter of an inch in size. In other respects, the materials were prepared for digestion as described in (4) preceding.

TABLE XIV.—SHOWING INFLUENCE OF MECHANICAL DIVISION OF CHEESE ON DIGESTION.

MATERIAL.	Total nitrogen in each bottle.	Hydro-chloric acid used in digestion.	Percentage of Nitrogen in Material in Form of Water-Soluble Nitrogen.				
			In 4 hours.	In 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Grams.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1. Cottage cheese ground fine	0.772	0.4	78.11	91.20	92.49	90.81	90.42
2. Cottage cheese, not ground	0.772	0.4	68.27	75.39	89.90	88.86	97.53
3. Cheddar cheese, ground fine	0.772	0.4	63.08	72.80	80.32	76.04	83.28
4. Cheddar cheese, chopped fine	0.772	0.4	34.07	55.54	65.16	78.50	81.87
5. Cheddar cheese in one-fourth inch cubes	0.772	0.4	18.27	29.92	50.78	64.52	69.17

The difference of digestion between the finely ground cottage cheese and that left in the ordinary condition is not large and after 24 hours nearly disappears. In the case of the cheddar cheese the difference is very striking. In the case of the cheese ground fine, about twice as much is digested in 4 hours as in case of that chopped fine and about three and one-half times as much as in case of that cut in one-quarter inch cubes. The cottage cheese that was in its ordinary condition digested more rapidly than the cheddar cheese ground fine.

(7) *Influence of increasing amounts of acid upon digestion of cheese.*—In normal gastric digestion in animals, the acid used is secreted gradually and not all poured into the stomach at the start. In order that the condition of our work might in this respect more nearly approximate normal digestion, we prepared for digestion, as described in (6) preceding, some samples of cottage and cheddar cheese, ground with sand, and added to the digesting mass hydrochloric acid at intervals, as follows: At start, 0.4 per ct. of acid; in 2 hours, 0.1 per ct.; in 4 hours, 0.1 per ct.; in 8 hours, 0.1 per ct.; in 24 hours, 0.1 per ct.; in 48 hours, 0.1 per ct.; making in all an addition of 0.9 per ct. of hydrochloric acid.

The results are given below in comparison with some disgestions in which 0.4 per ct. of acid was used at the start and none added afterwards.

TABLE XV.—SHOWING INFLUENCE OF INCREASING AMOUNTS OF ACID UPON DIGESTION OF CHEESE.

MATERIAL.	Total nitrogen in each bottle.	Hydrochloric Acid used in Digestion.		Percentage of Nitrogen in Material in Form of Water-Soluble Nitrogen				
		Added at start.	Added at intervals.	In 4 hours.	in 8 hours.	In 24 hours.	In 48 hours.	In 72 hours.
	Grams.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1. Cottage cheese	0.772	0.4	......	78.11	91.20	92.49	90.81	90.44
2. Cottage cheese	0.772	......	0.9	86.54	93.91	94.56	91.96	93.26
3. Cheddar cheese....	0.772	0.4	......	63.08	72.80	80.32	76.04	83.28
4. Cheddar cheese....	0.772	......	0.9	78.10	75.91	80.97	87.95	90.68

The addition of 0.4 per ct. of hydrochloric acid at the beginning of the digestion, followed by an addition of 0.1 per ct. 2 hours after, increased the amount of digested proteid very noticeably at the first examination, 4 hours after the digestion began. This was true in both cottage and cheddar cheese. As in previous cases, the cottage cheese was more completely digested than the cheddar cheese.

(8) *Summary of results of digestion experiments.* (a) *In the absence of acid,* paracasein fails to be digested by pepsin, while paracasein monolactate (the chief nitrogen compound of fresh cheddar cheese) paracasein dilactate, casein monolactate, and casein dilactate (cottage, or Dutch, cheese) are partially digested. Paracasein monolactate and casein monolactate, in the absence of acid, are digested more than are paracasein dilactate and casein dilactate.

(b) *In the presence of* 0.4 *per ct. of hydrochloric acid,* paracasein dilactate is digested by pepsin more than is paracasein monolactate. Paracasein monolactate and dilactate and casein monolactate and dilactate and casein dihydrochloride digest more readily and extensively in the presence of free hydrochloric acid than in its absence.

(c) Casein dilactate and casein dihydrochloride do not differ in the rapidity and extent to which they are converted into soluble compounds by pepsin.

(d) The addition of acid after the beginning of the digestion increases the amount of proteid digested, whether we use cottage cheese or cheddar cheese.

(e) Cottage cheese made from whole milk digests more rapidly than that made from skim-milk, owing to the looser texture of the former. Fat in such cases does not impede digestion.

(f) The rapidity of digestion is dependent in part upon the fineness of division of the material to be digested. Cottage cheese as ordinarily consumed is in a state of finer division than cheddar cheese.

(g) Cottage cheese may be properly regarded as more readily digestible than new cheddar cheese for two reasons: First, the casein dilactate, the chief constituent of cottage cheese, is more digestible in the presence of free hydrochloric acid than is paracasein monolactate, the principal nitrogenous constituent of new cheddar cheese. Second, cottage cheese is in such a mechanical condition that it admits of easier attack by digestive agents than does new cheddar cheese.

DESCRIPTION OF METHODS USED IN THE MANUFACTURE OF COTTAGE, OR DUTCH CHEESE.

We will now give in systematic form the details of the methods that we have by our work found practicable in the manufacture of cottage cheese.

(1) *Material to use.*—Skim-milk should be used. While whole milk can be used, so much fat is lost that there is serious waste of this valuable constituent.

(2) *Preparation of "starter."*—In manufacturing cottage cheese on a large scale, saving of time is usually effected by using a starter to hasten the souring of the milk. The character of the starter used is of much importance. Ferments other than acid-forming may be present in a starter and cause the formation of a slimy curd from which the whey can not be separated. It is essential, therefore, when one uses a starter, to give some attention to its preparation. The following is suggested as a method that will give good results, if properly carried out: Separator skim-milk, prepared from clean, fresh milk, is put into a carefully-cleaned receptacle, well covered and brought to a temperature of 90° F. (32° C.), after which it is placed where it will remain at a temperature of 65° F. to 70° F. (18° C. to 21° C.). In 20 to 24 hours, the skim-milk will be found properly ripened. In using this prepared starter, the upper portion to

the depth of one or two inches is removed and thrown away, the rest is strained through a fine strainer or hair sieve into the milk and thoroughly mixed. Some of this prepared starter may be used in preparing a starter for the day following, putting a little into some skim-milk that has been heated to 180° F. (82° C.) for thirty minutes and then cooled to 70° F. (21° C.) and allowed to stand 24 hours. The starter may thus be propagated from day to day. As soon as any unfavorable effect is noticed in curdling, a new started should be prepared.

There are on the market several different preparations for souring or ripening milk and cream, consisting of special cultures. Full directions for methods of use always accompany these special starters and we do not need to consider them here.

(3) *Manufacture of cottage cheese by ordinary souring of milk.* —The milk is kept at a temperature of 70° F. to 75° F. (21° C. to 24° C.) until it is well curdled, which will usually require 24 to 48 hours. The curdled mass is then broken up by hand or cut by a curd-knife and is heated gradually to 90° F. (32° C.) and is kept at this temperature until the whey appears clear. When the heat is so applied as to require 30 or 40 minutes to reach 90° F. (32° C.), then the whey will separate clear in 15 or 20 minutes under normal conditions. The whey is then run from the curd and the curd is put into muslin bags or placed on racks and allowed to drain until whey ceases to come from the curd. The curd is then salted at the rate of about one pound of salt for one hundred pounds of curd or to taste, shaped into balls and finally wrapped in oiled paper that may be obtained from any dairy-supply house. For the finest quality of cheese, the curd should be mixed with thick cream, preferably ripened cream, at the rate of one ounce of cream for one pound of cheese, before being made into balls.

(4) *Manufacture of cottage cheese when a starter is used.*—The starter, prepared as described above or by some equally good method, is added to the milk at the rate of 2 to 3 pounds to 100 pounds of milk and thoroughly mixed through the mass of milk. The rest of the operation is completed as described above under (3).

(5) *Manufacture of cottage cheese when rennet is used together with starter.*—The starter is added to the milk as described above

and *about 8 hours later* rennet extract is added at the rate of about 1 ounce for 1,000 pounds of milk. The rest of the operation is completed as described under (3) above.

(6) *Manufacture of cottage cheese by direct addition of hydrochloric acid.*—The milk should be at a temperature between 70° F. and 80° F. (21° C. and 27° C.). Measure out hydrochloric acid, of specific gravity 1.20, at the rate of 10 ounces for 100 pounds of milk, dilute this with ten times its bulk of water and add to the milk gradually, stirring the milk constantly while the acid is being added. The stirring is continued until the curd separates fully, leaving a clear whey entirely free from milkiness. As soon as this is accomplished, the whey is run from the curd and the rest of the operation completed as described under (3) above. Some care should be exercise in regard to the quality of the hydrochloric acid used. The kind usually kept at drug stores is not pure enough. The right kind of hydrochloric acid can be obtained from the Baker & Adamson Chemical Co., Easton, Pa., by ordering "hydrochloric acid, c. p., sp. gr. 1.20," and the cost in 5 pt. bottles is 7½ cents net a pound, or in carboys at 7 cents net a pound.

QUALITIES OF COTTAGE CHEESE.

The qualities that determine in the greatest degree the value of cottage cheese as an article of commerce are flavor and texture. The flavor should be that of mildly soured milk or well-ripened cream. There should be an entire absence of all objectionable flavors, such as bitter taste, flavor of stable, etc. If the cheese tastes too sour, it is probably due to the retention of too much whey. The use of a good starter will usually insure the right kind of flavor. The texture of cottage cheese, as we have already pointed out, is largely dependent on the amount of moisture retained in the cheese, and this in turn, is dependent largely upon the temperature at which the curdled mass of milk is heated and the length of time the heat is applied. Heating the coagulated mass above 100° F. (38° C.) for a very short time will make the cheese too dry and the texture crumbly. Heating below 90° F. (32° C.) for too short a time will make it impossible for the whey to drain from the curd satisfactorily and the cheese will be soft and mushy. For the soft, smooth texture that is to be desired, a moisture content of 70 to 75 per ct. is required. When the percentage of moisture drops much below 70, the cheese is harsh, dry and saw-dust like. The addition of cream to such cheese may improve it but cannot entirely overcome the effect of expelling too much moisture from the curd.

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THE NATURE OF THE PRINCIPAL PHOSPHORUS COMPOUND IN WHEAT BRAN.*

A. J. PATTEN AND E. B. HART.

SUMMARY.

1 Practicably all of the soluble phosphorus of wheat bran is of an organic nature.

2 The organic compound exists in the bran itself as a magnesium-calcium-potassium salt of a phospho-organic acid.

3 The free acid corresponds to the formula $C_2H_8P_2O_9$ and is probably identical with Posternak's anhydro-oxymethylene diphosphoric acid.

4 The alkali salts of this acid are freely soluble in water. The calcium and copper salts are slightly soluble while the barium and strontium salts are but sparingly so.

5 The acid and its salts seem to be of wide distribution in the vegetable kingdom, having already been isolated from the seeds of red fir, peas, beans, pumpkin, red and yellow lupine, also from the potato and other tubers and bulbs.

This investigation forms part of the research on the metabolism of phosphorus and sulphur in the animal body conducted under the direction of Dr. Jordan. The physiological role of the acid and its salts in animal metabolism will be made the subject of future researches.

INTRODUCTION.

From the work reported in Bulletin No. 238 of this Station and from other work done preliminary to an investigation of the metabolism of phosphorus in animals, it was found that in many of our ordinary feeding stuffs a varying percentage of the organic phosphorus is directly soluble in water and in dilute hydrochloric

*Reprint of Bulletin No. 250.

acid. Data illustrating this point will be found in the following table:

TABLE I.—SOLUBLE PHOSPHORUS IN OATS, MALT SPROUTS AND WHEAT BRAN.

	Total phosphorus.	Solvent.	Soluble phosphorus.	Percentage of total phosphorus.
	Per ct.		Per ct.	Per ct.
Oats	0.355	Water	0.180	50.0
		Hydrochloric	0.096	27.0
Malt sprouts	0.677	Water	0.548	81.0
		Hydrochloric	0.477	70.0
Wheat bran	1.22	Water	1.056	86.5
		Hydrochloric	0.95	77.8

It will be seen that wheat bran carries a much larger percentage of phosphorus than any of the others and that 86.5 per ct. is soluble in water.

It was at first supposed that the soluble phosphorus was in combination as nucleins or salts of nucleic acid, but determinations of the amount of soluble nitrogen showed that only about 33 per ct. of the phosphorus could be accounted for in this way. We were therefore led to the conclusion that by far the greater part of the soluble phosphorus was linked up in some other organic combination, since Hart and Andrews[1] have shown that the amount of soluble inorganic phosphorus is exceedingly small.

INVESTIGATION OF PHOSPHORUS COMPOUND.

ATTEMPT TO ISOLATE.

Two pounds of wheat bran was extracted with six liters of 0.2 per ct. hydrochloric acid for several hours with frequent stirring. The extract was strained through cheese cloth and finally filtered through paper.

The filtrate was treated with a large volume of 95 per ct. alcohol which threw down a voluminous, flocculent precipitate. The precipitate was allowed to settle to the bottom, the supernatant liquid syphoned off and the precipitate washed with alcohol several times by decantation. It was then dissolved in a small volume of 0.2 per ct. hydrochloric acid, filtered from an insoluble residue, reprecipitated by alcohol and washed as before by decantation.

[1] Bulletin 238, N. Y. Agr. Expt. Station.

This process was again repeated, the precipitate finally brought upon a filter, washed with absolute alcohol and ether and dried at 110° C. The resulting product, which weighed 7.2 grams, was a white amorphous powder readily soluble in water.

Its water solution was acid to litmus and it was precipitated from such solution by solutions of salts of the heavy metals, by the alkali metals and the alkaline earths, also by alcohol and ether.

Chemical analysis showed it to be an organic phosphorus compound coupled with calcium, magnesium and potassium.

Of this substance,

0.5004 gms. gave 0.0082 gms. CaO and 0.1327 gms. $Mg_2 P_2 O_7$ equivalent to 1.13 per ct. Ca and 5.80 per ct. Mg;

0.512 gm. substance gave 0.0834 gm. $K_2 Pt Cl_6$ equivalent to 2.60 per ct. K.

0.2174 gm. substance gave 0.1280 gm. $Mg_2 P_2 O_7$, equivalent to 16.38 per ct. P.

0.2122 gm. substance gave 0.1438 gm. CO_2 and 0.072 gm. $H_2 O$, equal to 18.52 per ct. C and 3.83 per ct. H.

The substance carried also a small amount of nitrogen (0.37 per ct.); but this was considered an impurity and, calculated as a proteid, would lower the carbon and hydrogen to 17.30 per ct. and 3.63 per ct. respectively.

COMPOSITION OF ISOLATED PHOSPHORUS COMPOUND.

	Per ct.		*Per ct.*
C	17.30	Ca	1.13
H	3.63	Mg	5.80
P	16.38	K	2.60

SIMILAR COMPOUNDS REPORTED BY OTHER WORKERS.

Palladin,[2] working in Schulze's laboratory, isolated from the seeds of black mustard (*Sinapis nigra*) a highly phosphorized compound in combination with calcium and magnesium.

The seeds freed from fat were extracted with 10 per ct. sodium chloride solution, filtered, and the filtrate heated to about 80° C. A precipitate separated carrying with it all of the proteid. The

[2] Beiträge zur Kenntniss plfanzlicher Eiweisstoffe, *Zeitschrift f. Biologie*, Jahrgang 1894, p. 199.

larger part of the precipitate went into solution again on cooling leaving the coagulated proteid in suspension, which was separated by filtration. The filtrate was again heated and the resulting coagulum collected on a hot water funnel.

Schulze and Winterstein[3] continued the investigation started by Palladin and obtained a compound carrying 9.65 per ct. C 2.83 per ct. H and 16.13 per ct. P. They thought the substance might be identical with the chief constituent of the globoids found enclosed in the protein kernel of many plant seeds. Pfeffer[4] in conjunction with Brandau found that such globoids consist of a calcium-magnesium salt of an organic body coupled with phosphoric acid. What the nature of this organic combination was they were unable to say.

Winterstein[5] isolated a compound from the seeds of black mustard by extracting with dilute acetic acid. The extract was freed from proteid by boiling and filtering when cold. The filtrate was made slightly alkaline with ammonium hydrate and boiled, the resulting precipitate collected on a hot water funnel and washed with hot water until the wash water reacted neutral. The substance was purified by dissolving in dilute acetic acid and reprecipitating with ammonium hydrate. On removing the calcium with oxalic acid, a product was obtained carrying 18.44 per ct. P and 7.83 per ct. Mg. By heating the magnesium salt in a closed tube with concentrated hydrochloric acid for 30 hours, at a temperature of 130°—140° he obtained inosite as a cleavage product.

The compound obtained by us from bran by the alcohol method, though still impure, is undoubtedly identical with the one described by these investigators.

Posternak[6] isolated the compound from the seeds of red fir, pumpkin, peas, beans, white and yellow lupine and also from the

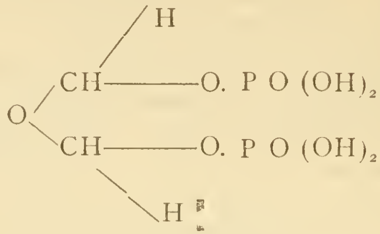
[3] Ueber einen phosphorhaltigen Bestandtheil der Plfanzensamen. *Zeit. f. physiol. Chem.*, **22**: 90.

[4] W. Pfeffer: Untersuchung ueber die Proteinkoerner und die Bedeutung des Asparagins beim Keimen der Samen. *Jahrbücher für wissenschaftliche Botanik.*, 8: 147. (1872).

[5] Ueber einen phosphorhaltigen Pflanzenbestandtheil, welcher by der Spaltung Inosit liefert. *Ber. d. deut. chem. Ges.*, **30**: 2299.

[6] *Revue Generale de Botanique.* **12**: 5 and 65, 1900.
Comptes Rendus, **137**: No. 3, (20 Juillet. 1903).
No. 5, (3 Aout 1903).
No. 8, (24 Aout 1903).

potato. He also isolated and identified the free acid as anhydro-oxymethylene diphosphoric acid with the following formula:



The method adopted by Posternak was the following:

The material was extracted with dilute hydrochloric acid and filtered, the filtrate was made alkaline with sodium hydrate and precipitated with calcium chloride. The calcium chloride precipitate was filtered, washed and finally dissolved in dilute hydrochloric acid. Sodium acetate was added to the solution to replace the free mineral acid by acetic acid, and copper acetate added in excess. The copper precipitate was filtered, thoroughly washed with water and decomposed by hydrogen sulphide.

The copper sulphide was removed by filtration and the excess of hydrogen sulphide removed by pumping air through the liquid. It was then evaporated in a vacuum over sulphuric acid.

We found it very difficult to remove the last traces of calcium by this method and have modified it by substituting barium chloride for calcium chloride. This admits of a very thorough washing at this stage of the operation as the barium salt is much more insoluble than the calcium salt and also admits of a complete removal of the barium as a sulphate.

METHOD OF PREPARATION OF FREE ACID.

The method finally adopted by us is as follows:

The bran was extracted with 0.2 per ct. hydrochloric acid, strained through cheese cloth and filtered through paper. Since the compound is present in bran as a calcium-magnesium-potassium salt, it was precipitated directly with copper acetate, by which means we were able to remove the greater part of these bases. After washing the copper precipitate it was suspended in water and decomposed by hydrogen sulphide. The filtrate from copper sulphide was made alkaline with sodium hydrate and precipitated with barium chloride. The barium salt was washed until free from alkali, suspended in water, and dilute sulphuric acid added in sufficient quantity to decompose the salt and throw down the barium as a sulphate. After removal of the barium sulphate by filtration the filtrate was again precipitated in alkaline solution with barium chloride and treated as before. This process was repeated a third time and after final removal of the barium, copper acetate was added in excess. The copper precipitate was filtered at the pump, thoroughly washed with water and finally suspended in water and decomposed by hydrogen sulphide. The copper sulphide was removed by filtration and the filtrate evaporated on the water bath to a syrupy consistency.

Analysis of the acid dried at 110° gave the following results:

0.7207 gm. substance gave 0.2811 gm. CO_2 and 0.2202 gm. H_2O equivalent to 10.63 per ct. C and 3.38 per ct. H.

0.1039 gm. substance gave 0.097 gm. $Mg_2P_2O_7$ equivalent to 25.98 per ct. P.

	Found.	Calculated for $C_2H_8P_2O_9$
C	10.63	10.08
H	3.38	3.36
P	25.98	26.07

DECOMPOSITION OF COMPOUND INTO INOSITE AND PHOSPHORIC ACID.

Heated with concentrated mineral acids it is broken up quantitatively into inosite and phosphoric acid, after the following equation.

$3\ C_2H_8P_2O_9 + 3\ H_2O = (CH\ OH)_6 + 6\ H_3PO_4.$

Posternak obtained 97.8 per ct. of the total carbon of the acid decomposed as inosite. In our investigation an unweighed portion of the acid was heated in a closed tube with 50 c. c. of 30 per ct. sulphuric acid at a temperature of 155°—160° for 5 hours. After cooling, the tube was opened and the contents washed into a beaker. The sulphuric and phosphoric acids were removed by barium hydrate and the excess of barium by carbon dioxide. The filtrate was evaporated nearly to dryness, taken up with hot water and filtered from remaining barium carbonate. The filtrate was then treated with absolute alcohol and ether until a cloudiness was produced, when it was allowed to stand in the cold. A crystalline precipitate soon separated which was obtained pure after once recrystallizing. It gave the reactions of Scherer and Gallois and melted at 218°—219° (uncor.). Inosite melts at 218° (uncor.).

Carbon and hydrogen determinations were made on the substance dried at 110°.

	Found.	Calculated for Inosite $C_6H_{12}O_6$
C.	39.59	40.00
H.	6.78	6.66

PROPERTIES OF ANHYDRO-OXYMETHYLENE DIPHOSPHORIC ACID.

The free acid dried slowly over sulphuric acid is a very thick, transparent liquid, of a yellowish brown color. It is soluble in all proportions in water and alcohol, insoluble in ether, benzene, chloroform and glacial acetic acid. It has a very sharp acid taste. Heated to 110° it becomes decidedly brown without decomposition. The alkali salts of the acid are freely soluble in water. Water solutions of the free acid are precipitated by ferric chloride, the precipitate being soluble in an excess of the reagent. Silver nitrate precipitates solutions of the free acid only after a liberal excess of the reagent has been added. The precipitate is insoluble in excess of the reagent. The free acid is not precipitated by the chlorides of magnesium calcium barium or strontium, due to the liberation of free hydrochloric acid. However, when solutions of the alkaline salts of the free acid are treated with the above re-agents, a precipitate is formed.

The magnesium and calcium salts are somewhat soluble in water, the barium and strontium salts, very sparingly soluble. The magnesium salt is easily soluble in acetic acid. The calcium salt less so while the barium and strontium salts are very insoluble. All are readily soluble in mineral acids.

The free acid is tetra basic and forms two salts, the one a normal salt, the other an acid salt. The normal salt reacts neutral to phenolphthalein while the acid salt reacts neutral to methylorange which may be shown by the following determinations: 10 c. c. of a solution containing 0.0648 gm. of the acid titrated in phenolphthalein with deci-normal barium hydrate required 109 c. c. or 0.0748 gm. barium, 0.0648 gm. of the acid should require 0.0749 gm. barium to produce the normal salt (C. H. P. O. Ba.) 10 c. c. of the same solution titrated to methylorange with deci-normal barium hydrate required 5.1 c. c. of 0.035 gm. barium. 0.0648 gm. of the acid should require 0.0343 gm. barium to produce the acid salt (C. H. P. O. Ba.).

QUANTITATIVE ESTIMATION OF THE ACID IN WHEAT BRAN.

We extracted 10 gms. of bran of 500 c. c. with 0.2 per ct. hydrochloric acid, made 100 c. c. alkaline with sodium hydrate, precipitated with barium chloride filtered and washed free from alkali.

The phosphorus was determined directly in this precipitate:

Total phosphorus, per cent	1.25
Phosphorus in barium precipitate, per cent	0.92
Per cent. of phosphorus barium precipitate to total phosphorus, per cent	58.1

Practically all of the phosphorus soluble in 0.2 per ct. hydrochloric acid is in this form as is shown below:

Total soluble phosphorus, per cent	0.94
Phosphorus in barium precipitate, per cent	0.92
Per cent. of phosphorus barium precipitate to soluble phosphorus, per cent	97.9

THE COMPOSITION OF COMMERCIAL SOAPS IN RELATION TO SPRAYING.*

L. L. VAN SLYKE AND F. A. URNER.

SUMMARY.

1. *Object.*—The object of the work discussed in this bulletin was to ascertain why commercial whale-oil soaps in some cases fail to detroy insects and in some cases cause injury of foliage.

2. *What a Soap is.*—A soap is made by treating a fat or oil with an alkali, as caustic soda or potash. A soap is a chemical compound formed by the union of an alkali and the fatty acid or acids contained in a fat or oil.

3. *Results of Analysis of Commercial Whale-Oil Soap.*—The important constituents of a soap in relation to spraying are (a) water, (b) actual soap, and (c) free alkali. In the case of nine samples of commercial whale oil soap, the percentage of water varied from about 11 to 55 per ct.; of actual soap from about 15 to 60 per ct.; of free alkali from nothing to 1.30 per ct. Two different lots of soap from the same factory contained 36.79 and 53.13 per ct. of water and 24.06 and 46.28 per ct. of actual soap.

4. *Results of Variation in Composition of Commercial Whale-Oil Soaps.*—In making solutions of different commercial whale-oil soaps, one can not be sure of having a uniform strength of solution and this lack of uniformity seriously affects their value for spraying purposes.

5. *Home-manufacture of Fish-Oil Soap.*—In order to have a soap of uniform composition, the following formula may be suggested: Caustic soda, 6 pounds; fish oil, 22 pounds; water, 1½ gallons. This will make 40 pounds of soap. Certain precautions given in detail in the text of the bulletin should be carefully observed.

*Reprint of Bulletin No. 257.

6. *Experiments in using Home-made Soap in Spraying.*—The home-made soap, when used at the rate of one pound in seven gallons of water, gave entire satisfaction in every way on the foliage of apple, pear, plum, currant, cherry and peach trees. The foliage was not injured and plant lice were destroyed.

7. *Experiments in Spraying with Soap containing Free Alkali.*—Soaps were made so as to contain 1, 2, 5, 10, 20 and 50 per ct. of free alkali. These were used in the same strength of solution and on the same kinds of foliage as given above. Injury was done when the free alkali reached 10 per ct. Little injury was done by the use of soap containing 5 per ct. or less of free alkali.

8. *Cost of Home-made Soap.*—Caustic soda can be purchased at 4½ cents a pound and fish-oil at 26 to 30 cents a gallon. On the basis of these figures, the cost of the materials used in making one pound of fish-oil soap is about 2¾ cents.

9. Advantages of home-made fish-oil soap are (1) greater uniformity of composition, (2) greater reliability, (3) decreased cost.

INTRODUCTION.

The work embodied in this bulletin was suggested by the complaints that have been made in respect to the unsatisfactory results frequently experienced in the use of so-called whale-oil soap when used on orchards for the purpose of destroying certain forms of insects. The disappointing results reported vary in character; in some cases the insects are only incompletely destroyed; in other cases, the foliage is killed and the trees also. The uncertainty of the results of applying this remedy has caused no little uneasiness among fruit growers and numerous letters have come to this Station asking for information in regard to the use of whale-oil soap. As a result of this condition, the Station entomologist, Mr. P. J. Parrott, suggested that we take up the subject for investigation.

There are on the market many different brands of whale-oil soap, and it occurred to us that there must be marked variations in the character of different brands to account for the great difference reported in the results of their use. There is no known recognized standard of composition for this class of soaps and, as a starting point of our investigation, it seemed necessary to obtain a more complete knowledge of the composition of the varieties of whale-oil soap found in the market.

It may be stated here at the outset that many commercial whale-oil soaps contain no whale-oil proper, but the term "whale-oil" is applied to any kind of fish-oil soap, and the oil of such fish as the menhaden has come to be largely used as a substitute for more expensive oils.

Before taking up our chemical study of soaps, we will call attention, in passing, to the reason why fish-oil soaps are used as extensively as they are. Destructive insects cause injury in two ways, first by destroying portions of the foliage by direct biting or cutting out pieces of the leaves, and, second, by sucking the juices of the plant. The insects causing injury in the first way are readily killed by applying insect poisons to the foliage. The sucking insects, among which the San José scale and plant lice are the most common, are not killed by the application of ordinary insect poisons. They can be killed only by what is known as a "contact remedy," which is either a fluid that penetrates the spiracles or breathing holes, filling them up and thus causing death, or is a water-solution of some substance, which, when the water evaporates, remains as a thin coating over the insects, thus covering the spiracles and preventing breathing. Whale-oil soap is a contact remedy of the second kind and, owing to the rapid spread in recent years of plant lice and scale, has become most important on account of its very extended application, being used probably more than any other contact remedy.

It is supposed by some that whale-oil soaps possess in themselves some peculiar value for destroying insects, and this opinion might appear to be justified by the extreme offensiveness of the odor, but as a matter of fact any good soap possesses just as much value for this purpose, the preference shown for fish-oil soaps being due solely to their relative cheapness.

THE COMPOSITION OF WHALE-OIL SOAPS.

There were collected for analysis nine different brands of commercial whale-oil soap, some being obtained directly from manufacturers, some by private purchases and others from supplies on hand at the Station.

WHAT SOAPS IN GENERAL ARE.

Before presenting the results of analysis, we will consider briefly the chemistry of soaps. Soaps are made by treating fats or oils with a caustic alkali, caustic soda being used in making hard soap and caustic potash in making soft soap. A real chemical combination occurs between the alkali and the fat or oil. Thus a fat or oil is generally a mixture of several compounds, each of which contains glycerine in chemical combination with certain acids, most commonly what are known as "fatty" acids. When a fat or oil is treated with caustic soda, the sodium takes the place of the glycerine and unites with the fatty acids, forming a sodium compound of each of the fatty acids, and the glycerine that was in combination is set free as glycerine. In some cases, boiling is necessary to cause the alkali and fatty acid to combine; in other cases, the action takes place at ordinary temperatures. A soap is, therefore, a chemical compound formed by the union of an alkali with the fatty acid or acids of a fat or oil. Other substances are frequently added to soaps for various purposes, such as resin, water, coloring matter, perfume, etc.

EXPLANATION OF TERMS USED IN ANALYSIS OF SOAPS.

The terms commonly used in expressing the results of analysis of a soap, when it is desired to determine its fitness for spraying purposes are the following. (1) Water, (2) fatty acids expressed as anhydrides, (3) sodium oxide combined as soap, (4) potassium oxide combined as soap, (5) resin, (6) free acid estimated as oleic acid, (7) free alkali.

(1) *Water in soap.*—It is desirable to know the amount of moisture in soap in order to know its value for spraying purposes, since the greater the amount of water in the soap, the more soap will be needed to make a soap solution of a certain strength.

(2) *Fatty acids expressed as anhydrides.*—Under this heating, we indicate simply the proportion of fatty acids present in the soap.

(3) *Sodium oxide combined as soap.*—In order to know the kind and amount of alkali present in a soap, it is necessary to

determine the amount of sodium, expressed as oxide, that is actually present in combination in the soap.

(4) *Potassium oxide combined as soap.*—When a soap is guaranteed to contain potash, it is important to ascertain how much is present, since potash costs more than caustic soda. In an ordinary soda soap, it is not important to determine the potash.

(5) *Resin.*—To many soaps resin is added apparently for the purpose of enabling the soap to hold water, making it harder and of increasing the weight.

(6) *Free fatty acid.*—In making a soap, more fat or oil may be used than can combine with the alkali used and then some uncombined fat or oil will be left over. This is indicated under the expression "free fatty acid." The same condition may occur when the combination of fat and alkali is incomplete.

(7) *Free alkali.*—When more alkali is used than can combine with the fat or oil used or when the combination is incomplete, free alkali is left in the soap. This condition in spraying soaps may prove injurious to foliage.

RESULTS OF ANALYSIS OF WHALE-OIL SOAPS.

In the following table, we present the results of analysis of 9 samples of commercial whale-oil soap. Ordinary impurities were not determined. Potash was estimated only in those advertised as potash soaps. The amount of actual soap is found by adding the constituents, anhydrides of fatty acids, soda and potash.

TABLE I.—GIVING RESULTS OF ANALYSIS OF WHALE-OIL SOAPS.

No. of sample.	Water.	Actual soap.	Fatty acid expressed as anhydrides.	Soda (Na_2O) combined as soap.	Potash (K_2O) combined as soap.	Free fatty acids.	Free alkali as soda (Na_2O)	Resin.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	11.15	59.27	50.84	8.43	0	11.14	0.00	12.65
2	20.38	36.66	25.87	10.79	0	3.95	0.00	51.60
3	28.39	14.90	8.05	6.85	0	0.00	1.30	20.58
4	29.4	50.27	39.11	11.16	0	14.66	0.00	4.99
5	29.75	19.66	12.07	7.59	0	10.01	0.00	33.17
6	36.79	46.28	35.82	4.88	5.58	12.41	0.00	8.25
7	52.74	25.80	16.40	2.33	7.07	10.72	0.00	10.57
8	53.13	24.06	19.12	1.95	2.99	17.20	0.00	——
9	54.85	24.11	15.27	1.89	6.95	9.02	0.00	7.98

The tabulated data of special interest that enable us best to estimate the value of a soap for spraying purposes are the following: Water, actual soap, free fatty acids and free alkali. What does this table reveal in regard to the presence of these various constituents in the different soaps?

(1) *Water* in the nine samples various from 11.15 to 54.85 per ct. No. 6 and No. 8 are different lots of the same brand of soap, but the content of water differs over 16 per ct.

(2) *Real soap* in the different samples varies from 14.90 to 59.27 per ct., a range of difference even greater than in the case of the water in these soaps. In samples 6 and 8, which represent different lots of the same manufacturer's material, the real soap is nearly twice in amount in No. 6 what it is in No. 8.

(3) *Free fatty acids* varied from nothing to 17.20 per ct. indicating in most cases that the oil was used in amount more than sufficient to combine with alkali.

(4) *Free alkali* was generally absent, being found in only one soap and then not in excessive amount, indicating that not enough oil was employed to combine fully with the alkali.

It is evident, then, that these whale-oil soaps, which were actually found offered for general sale in the market, are absolutely unreliable for anything like uniform composition. An inspection of the data in the preceding table must readily reveal why a fruit-grower who uses a soap like No. 3, containing less than 15 per ct. of soap, will fail to get satisfactory results as compared with the one who uses No. 1 or No. 4, which contain over 50 per ct. of actual soap. A man purchasing No. 6, containing over 46 per ct. of actual soap, and using it with success might at the next purchase get No. 8, the same brand as No. 6, but containing only 24 per ct. of soap, and then be puzzled to know why the soap failed to destroy the insects. Some of these soaps when used according to the usual directions, give a solution four times as strong as some of the other soaps. Suppose, for illustration, one uses No. 1 soap at the rate of one pound to seven gallons of water; in order to have a solution contain the same amount of soap, it would be necessary to use four pounds of No. 3 for seven gallons of water. In the case of No. 6 and No. 8, the same directions for use accompanied both lots and yet one contained twice as much actual soap as the other.

The variation of the soaps in water content did not account for all the differences of actual soap. Thus, No. 3, No. 4 and

No. 5 contain about the same amount of water but the actual soap in them varies from 14.90 to 50.27 per ct.

It is a fact that very few makers of commercial whale-oil soaps are willing to guarantee the composition of their product. It would, therefore, appear that horticulturists cannot depend upon the whale-oil soaps in the market as possessing a standard, or uniform, composition. The question arises as to how one can know how much commercial whale-oil soap to use under the circumstances. The only practicable suggestions are either to make up solutions of different strength and try them in a small way on foliage, thus ascertaining how much soap to use, or else to purchase reliable materials and make soap for one's own use.

EXPERIMENTS IN THE HOME-MANUFACTURE OF FISH-OIL SOAP.

It was thought desirable under the circumstances to try some experiments in making fish-oil soap and to find a formula that could be recommended as giving results in every way satisfactory. Two formulas were tried. The materials used were common fish-oil, caustic soda and water. The quantities given are based on a finished product of 40 pounds of soap. In making the soap, the caustic soda is completely dissolved in the given amount of water and the fish-oil is then added gradually under constant and vigorous stirring. The combination occurs readily at ordinary summer temperatures and the operation is soon completed. The mixing may be done in any receptacle sufficiently large to contain the whole amount of material. It would probably not be desirable to attempt to make more than 20 to 40 pounds at a time, since the difficulty of thoroughly stirring a larger mass would tend to make a complete combination less sure, thus rendering liable the presence of too much free alkali. *Complete and thorough stirring is essential to success.* Caustic soda should be handled with precaution, since in concentrated form it easily injures the skin.

NO. 1. FORMULA FOR MAKING 40 POUNDS OF FISH-OIL SOAP.

Caustic soda	6	pounds.
Water	1½	gallons.
Fish-oil	22	pounds.

This was found to show on analysis,—

Water	24.91 per ct.
Actual soap	61.57 per ct.
Free alkali	0.74 per ct.

A 20-pound lot made up at another time contained 0.62 per ct. of free alkali.

No. 2. Another mixture was made containing twice as much caustic soda and less fish-oil. This contained,—

Water	23.36 per ct.
Actual soap	47.79 per ct.
Free alkali	11.22 per ct.

EXPERIMENTS IN USING HOME-MADE SOAPS IN SPRAYING.

Experiment 1.—*Action on aphis of willow.*—Soap No. 1 was used in solutions of three different strengths (one pound of soap in two, five, and seven gallons of water) upon willow leaves infected with the willow aphis (*Lachnus salicicola* Uhler). The insects were completely destroyed by each of the three solutions. The success of this home-made soap in solution of at least one pound of soap in seven gallons of water was thus shown in destroying aphis.

Another point, however, demanded attention, the effect of free alkali in a soap solution upon the foliage itself. To test this a series of additional experiments was carried on.

Experiments testing action of home-made soap containing different amounts of free alkali upon foliage.—In the following set of experiments, the solutions used contained one pound of soap in seven gallons of water. Soap No. 2, containing 11.22 per ct. of free alkali, was used without any addition of alkali. Soap No. 1 was used in its normal condition, containing 0.75 per ct. of free alkali, and also with added quantities of caustic soda, making the amount of free alkali in the soap 1, 2, 5, 10, 20 and 50 per ct. of the soap.

(1) June 22, apple, pear, plum and currant leaves were sprayed with solutions of soap containing 0.75, 1, 2, 5 and 10 per ct. of free alkali. A fine rain was falling while the trees were being sprayed and the results of the experiment must be interpreted

with reference to this condition. The leaves were examined on the second and third day after spraying. On the second day after spraying, only the young apple leaves showed signs of burning and that was by the one solution made from soap containing 10 per ct. of free alkali. When examined on the third day after spraying, the apple leaves appeared the same as on the previous day, the plum and currant leaves showed no appreciable harm, and the pear foliage was unharmed except for a slight burning at the ends of the leaves by the solution of the soap containing 10 per ct. of free alkali.

(2) June 23, apple, pear, plum and cherry foliage was dipped in solutions of soap containing 0.75, 2, 5, 10 and 20 per ct. of free alkali and also in a solution of soap No. 2 containing 11.22 per ct. of free alkali. When examined on the next day, no harm was shown by any of the leaves except the young leaves of the apple in the case of the largest amounts of free alkali. It was noticed that a lady-bird beetle on the foliage was killed by the solution of the soap that contained 20 per ct. of free alkali. When examined on the second day after spraying, the following results were observed:—The apple leaves treated with soap containing 0.75, 2 and 5 per ct. of free alkali were not injured; those treated with the soap containing 10 and 11.22 per ct. of free alkali were slightly burned, while the soap containing 20 per ct. of free alkali caused serious injury.

The pear foliage suffered no injury from soap containing five per ct. or less of free alkali, while injury was caused by the soap containing 10 per ct. or more of free alkali, the extent of injury increasing with the amount of free alkali present.

The plum foliage suffered no injury except very slight burning in the case of the solution made from the soap containing 20 per ct. of free alkali.

The cherry leaves were injured by solutions made from soap containing 10 per ct. or more of free alkali.

(3) June 24, apple, pear, plum, currant, cherry, and peach leaves were treated with a solution made from a soap containing 50 per ct. of free alkali. In every case, the leaves were badly burned, as might be anticipated.

These results are presented below in tabulated form.

TABLE II.—SHOWING RESULTS OF ACTION OF FREE ALKALI IN SOAP ON FOLIAGE.

Kind of foliage.	When treated.	When examined.	Extent of Injury Done to Foliage by Free Alkali in Soap. Percentage of Free Alkali in Soap from which Solutions were made.							
			0.75	1	2	5	10	11.22	20	50
Apple	June 22	June 24	None	None	None	None	Some	——	——	——
Apple	June 22	June 25	None	None	None	None	Some	——	——	——
Pear	June 22	June 24	None	None	None	None	None	——	——	——
Pear	June 22	June 25	None	None	None	None	Slight	——	——	——
Plum	June 22	June 24	None	None	None	None	None	——	——	——
Plum	June 22	June 25	None	None	None	None	None	——	——	——
Currant	June 22	June 24	None	None	None	None	None	——	——	——
Currant	June 22	June 25	None	None	None	None	None	——	——	——
Apple	June 23	June 24	None	——	None	None	Some	Some	Some	——
Apple	June 23	June 25	None	——	None	None	Some	Some	Serious	——
Pear	June 23	June 24	None	——	None	None	None	None	Slight	——
Pear	June 23	June 25	None	——	None	None	Slight	Some	Serious	——
Plum	June 23	June 24	None	——	None	None	None	None	None	——
Plum	June 23	June 25	None	——	None	None	None	None	Slight	——
Cherry	June 23	June 24	None	——	None	None	None	None	None	——
Cherry	June 23	June 25	None	——	None	None	Some	Some	Serious	——
Apple	June 24	June 27	——	——	——	——	——	——	——	Very serious
Pear.	June 24	June 27	——	——	——	——	——	——	——	Very serious
Plum	June 24	June 27	——	——	——	——	——	——	——	Very serious
Currant	June 24	June 27	——	——	——	——	——	——	——	Very serious
Cherry	June 24	June 27	——	——	——	——	——	——	——	Very serious
Peach	June 24	June 27	——	——	——	——	——	——	——	Very serious

The results of the experiments described above indicate that the presence of free alkali to the extent of five per ct. in soap does not injure foliage when the soap is made into a solution of one pound of soap in seven gallons of water. Comparatively little harm is done even when the amount of free alkali in a soap amounts to 10 per ct., the soap solution being of the same degree of dilution. It can readily be seen, therefore, that home-made soap No. 1, containing less than one per ct. of free alkali, can be safely used on all the varieties of foliage experimented with and can also be relied upon to destroy plant lice, when used in the form of a solution of one pound of soap to seven gallons of water.

COST OF MATERIALS USED IN HOME-MADE SOAP.

Caustic soda of good commercial quality (74 per ct.) can be purchased from the Penn Chemical Co., 1322 Washington avenue, Philadelphia, Pa., at about four cents a pound, f. o. b., put up in 50-pound cans. Making liberal allowances for freight and any incidental expenses, the cost of caustic soda should not exceed

$4\frac{1}{2}$ cents a pound. It can be purchased at drug stores for about 6 cents a pound.

We have been at considerable trouble to learn where fish-oil can be purchased. It can be furnished in barrel lots by the following parties:

Nehemiah B. Cook, 148 Front Street, New York City.

Swan & Finch Co., 151 Maiden Lane, New York City.

Refined fish-oil can be purchased in barrel quantities at 29 cents a gallon f. o. b. Crude fish-oil can be purchased under the same conditions at 25 cents a gallon and answers the purposes very satisfactorily.

From these data, we can estimate the cost of materials used in making soap according to the formula given, making some allowance for cost of shipping materials.

6 pounds caustic soda at $4\frac{1}{2}$ cents a pound.............	$0.27
22 pounds (about 3 gallons) fish-oil at 29 cents a gallon..	0.87
Total cost of materials used in making 40 pounds of soap.	1.14
Cost of one pound of soap.......................	2.85 cents

Commercial whale-oil soap costs at retail in small quantities 10 cents a pound; in larger quantities, six cents a pound. In barrel-lots, amounting to 350 to 400 pounds, whale-oil soap can be purchased in New York city at $4\frac{1}{2}$ cents a pound, and fish-oil soap at $3\frac{1}{2}$ cents a pound.

It would, therefore, appear that some saving may be effected in the home-manufacture of fish-oil soap for spraying purposes. Even if no saving could be made by home-manufacture, an article of greater uniformity and reliability could be secured and this would generally result in marked economy in comparison with using commercial soaps of uncertain and very variable composition.

A STUDY OF THE CHEMISTRY OF HOME-MADE CIDER VINEGAR.*

L. L. Van Slyke.

SUMMARY.

1. *Purpose of Work.*—The primary object of the work was to learn why many home-made cider vinegars fail to reach the legal standard of 4.5 per ct. of acetic acid and 2 per ct. of cider vinegar solids. The investigation was extended so as to include (1) the composition of apple juice of different varieties of apples, (2) the changes in composition that apple juice undergoes during alcoholic and acetic fermentations, (3) conditions affecting these changes and (4) the destructive fermentation of vinegar on long standing.

2. *Composition of Apple Juice.*—Analyses are given for 122 samples of apple juice representing 83 varieties of apples, all American-grown. The average composition of these juices is as follows:

Specific gravity,	1.056
Solids,	13.28 per ct.
Reducing sugars,	7.41 per ct.
Sucrose,	3.28 per ct.
Ash,	0.29 per ct.
Fixed acid (malic),	0.51 per ct.

Of these constituents, sugar is the most important in relation to the manufacture of cider vinegar. The quantity of sugar in apple juice is dependent upon the variety of apple and upon the stage of ripeness, unripe or over-ripe apples containing less sugar than ripe apples.

3. *Alcoholic Fermentation of Apple Juice.*—Apple juice left exposed to the air is acted upon by yeast cells everywhere present,

*A reprint of Bulletin No. 258.

the sugar being changed into alcohol and carbon dioxide gas. Theoretically, 100 parts of sugar should yield about 51 parts of alcohol, but in actual practice losses are experienced, reducing the actual yield to 45 to 47 parts of alcohol. The fresh apple juice from sound apples contains no alcohol. When apple juice has undergone partial or complete alcoholic fermentation, it is commerically known as " cider."

In carrying on the experiments, apple juice was placed in casks and also in bottles, and these were kept under different conditions, some approximating the conditions commonly employed by farmers in the home-manufacture of cider vinegar.

(1) *Relation of time to formation of alcohol.*—Under the ordinary conditions of a cellar temperature, most of the sugar is changed into alcohol in five or six months. (2) Relation of temperature to alcoholic fermentation. In studying the alcoholic fermentation at temperatures ranging from 45° F. to 85° F., it was found that the change takes place more rapidly at the higher temperatures. (3) Adding yeast to apple juice tends to hasten the alcoholic fermentation.

4. *Acetic Fermentation of Cider.*—Certain forms of bacteria act upon the alcohol of cider and convert it into acetic acid, the presence of which in sufficient quantity is the object of the maker of vinegar. The conditions most necessary for the acetic fermentation of cider are (a) acetic bacteria, (b) an abundant supply of air, and (c) a temperature between 65° F. and 85° F. Theoretically, 100 parts of alcohol yield about 130 parts of acetic acid, but the actual yield is usually below 120.

(1) *Relation of time to formation of acetic acid.*—At cellar temperatures, the acetic fermentation takes place slowly, requiring about 18 months. (2) *The relation of temperature to the acetic fermentation.*—Under the conditions of our work the formation of acetic acid took place most satisfactorily at temperatures between 65° F. and 75° F. (3) The addition of vinegar containing " mother " to cider after the completion of the alcoholic fermentation increases the rapidity of the formation of acetic acid. (4) When the clear portion of cider was separated from the sediment, the acetic fermentation appeared to be favored, especially at lower temperatures.

5. *Loss of Acetic Acid in Vinegar on Standing.*—Several different organisms have the power of decomposing dilute acetic acid and thus destroying the value of vinegar. These organisms work only in the presence of air. Accordingly, this destructive change in vinegar can be prevented by excluding air, when once the acetic acid has been formed. In practice, this can be done by drawing off the clear vinegar, placing it in a clean barrel, filling it as full as possible and putting the bung in tight.

6. *Variations in Vinegar made under Uniform Conditions.*—It is possible that different barrels of apple juice placed side by side may show quite different behavior in fermentation.

7. *Behavior of Malic Acid of Apple Juice during the Fermentation Processes of Vinegar-making.*—Malic acid was found to decrease during the vinegar-making process. In most cases, only small amounts of malic acid, free or combined, were left when the vinegar had become a commercial product. In decomposed vinegars, malic acid had entirely disappeared. Malic acid added to apple juice also disappeared to a large extent. In sterilized apple juice, the decrease of malic acid was less marked.

8. *The Relation of Malic Acid to the Identification of Pure Cider Vinegar.*—The white precipitate formed when lead acetate is added to vinegar has been attributed to the presence of malic acid in the vinegar and a vinegar failing to give this test is usually regarded as not cider vinegar. While all of our vinegars gave a precipitate with lead acetate, there were several in which no trace of malic acid was present. Further special study is needed of the relation of malic acid to cider vinegar.

9. *The Solids of Apple Juice and Cider Vinegar.*—During the first three months of the alcoholic fermentation at cellar temperature, the solids decreased rapidly. The loss was not uniform in different experiments. There is quite generally a decrease of solids to a point below 2 per ct., but under normal conditions there is a subsequent increase. In old vinegars, standing with the bung-hole open, there is evaporation of water and a consequent increase of solids. In vinegars in which a destructive fermentation of acetic acid has occurred, there is also a marked loss of solids. The amount of vinegar solids may be below 2 per ct. when the acetic acid is above 4.5 per ct.

10. *Cider Vinegar in Relation to Legal Standards.*—Legal standards for cider vinegar are usually based upon the percentage of acetic acid and cider-vinegar solids. In New York State, the legal requirement is 4.5 per ct. of acetic acid and 2 per ct. of solids. From our work, it appears that where proper fruit is used for cider-making and where the conditions of fermentation are properly controlled, there should be no difficulty in making cider vinegar that contains above 4.5 per ct. of acetic acid in 18 to 24 months.

In respect to the requirement of 2 per ct. of cider vinegar solids, something depends upon the method of determining solids, since there is yet no recognized official method. It would be wise for the law to fix the method to be used in estimating solids.

11. *Conditions commonly producing Cider Vinegar below Standard.*—The more common causes responsible for the production of cider vinegar low in acetic acid are the following:—(1) Poor apple juice, due to (a) unripe fruit, (b) over ripe fruit, (c) watering normal apple juice, (d) second pressing of water-treated pomace, (e) the use of fruit normally poor in sugar. (2) Conditions unfavorable to the necessary fermentation processes, such as (a) dirty fruit, (b) unclean barrels, (c) too low temperature, (d) lack of air from filling barrel too full or stopping the bung-hole. (3) Lack of proper care after the vinegar is made, by leaving the cider standing at too high a temperature with the bung open and the barrels only partly filled.

12. *Directions for Home-Manufacture of Cider Vinegar.*—(1) Kind of apples to use. Only clean, sound, ripe apples, giving a juice containing not less than 8.5 per ct. of sugar should be used. (2) Preparation of apple juice. Cleanliness should be observed in grinding and pressing. Avoid the use of juice made from second pressing of pomace. (3) Putting apple juice in barrels. The barrels should be carefully cleaned and thoroughly treated with live steam or boiling water and should be filled about two-thirds or three-fourths full of apple juice. The bung should be loosely placed in the hole or preferably the hole loosely plugged with a stopper of absorbent cotton. (4) Management of alcoholic fermentation. The barrels of apple juice should be kept at a temperature of 65° F. to 70° F., if fairly rapid fermentation

is desired. A further shortening of time may be realized by adding yeast to the apple juice, using one compressed yeast cake for five gallons of juice. (5) Management of acetic fermentation. When alcoholic fermentation is complete, draw off clear portion of liquid, rinse barrel, replace the clear liquid, add 2 to 4 quarts of good vinegar containing some " mother " and keep at a temperature of 65° F. to 75° F. (6) Care of cider vinegar. When the acetic acid amounts to 4.5 per ct. of acetic acid or more, then fill the barrels as full as possible and cork tightly.

INTRODUCTION.

Some years ago our attention was called to the fact that cider vinegar made by farmers was found frequently to fall below the legal standard of the State, viz., 4.5 per ct. of acetic acid and 2 per ct. of cider vinegar solids. It was commonly claimed that these vinegars were made from pure apple juice. The desire was expressed that a study should be made to ascertain why the cider vinegar made by farmers so frequently falls below the legal standard. The work described in this bulletin was undertaken primarily to throw some light on this question. Our original plan was to ascertain what results could be secured in making vinegar from pure apple juice under those conditions commonly employed by farmers. No attempt was made to study the rapid process of making vinegar by the use of so-called generators, since their use is greatly limited in ordinary farm practice.

The investigation was extended to the consideration of additional points of interest, such as (1) the composition of fresh apple juice obtained from different kinds of apples; (2) the changes in composition that the constituents of apple juice undergo (a) during alcoholic fermentation and (b) during acetic fermentation; (3) the conditions affecting these changes; (4) the destruction of vinegar on long standing. Somewhat similar work has been done at the experiment stations of Pennsylvania and Virginia and by the Bureau of Chemistry of the United States Department of Agriculture.

Up to July, 1901, Dr. J. A. LeClerc, formerly assistant chemist here, now of the Division of Chemistry, United States Department of Agriculture, performed most of the routine analytical work required by the investigation.

In the process of making vinegar from apple juice or "sweet cider," two fermentations are prominent and essential. Through the agency of the first form of fermentation, the sugars of the apple juice are converted into alcohol, and the product at this stage is commonly known as "hard" cider or simply cider. The alcohol is then converted by another form of fermentation into acetic acid, the product then being known as vinegar. In considering the formation of cider-vinegar, we have therefore to study two distinct processes of fermentation.

THE COMPOSITION OF APPLE JUICE.

Before considering the changes produced in apple juice by the fermentations that convert it into vinegar, we will study the composition of the juice freshly prepared from apples. In the preparation of the samples of apple juice used in our work, we selected standard varieties of apples; we used only well-ripened, sound fruit and prepared the samples in October and November. Before grinding, the apples were washed and then put through a large-sized hand-mill and press.

The apple juice was filtered before analysis in order to remove pulp and other suspended matter. The determinations in the apple juice, cider and vinegar were made as follows:—

The *specific gravity* was determined by means of a pyknometer.

The *solids* were found by drying about five grams of material on sand in a steam oven for six to eight hours.

The *sugars* were determined by the volumetric permanganate method, as described in Bulletin No. 46 of the Division of Chemistry, United States Department of Agriculture, p. 38.

The amount of *total acid* was found by direct titration. The volatile and fixed acids were determined as follows: About 10 grams of material were evaporated to dryness on a water bath, then a small quantity (about 5 cc.) of distilled water was added and the contents evaporated to dryness again. The addition of water and evaporation to dryness were repeated two or three times. The residue was then titrated with decinormal sodium hydroxide and the result calculated as malic acid. This amount deducted from the total acid gave the volatile acid, which was calculated as acetic.

The amounts of *alcohol*, of *ash* and of *nitrogen* were found by the methods in common use.

Below we give the results of analysis of 13 samples of fresh apple juice.

TABLE I.—ANALYSIS OF APPLE JUICE USED IN EXPERIMENTS.

No. of Ex'pt.	KIND OF APPLE.	Specific gravity.	Solids.	Reducing sugars.	Sucrose.	Nitrogen.	Ash.	Fixed acid as malic.	Volatile acid.
			Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	Northern Spy..........	1.064	15.24	10.08	2.69	.015	0.19	0.52	.02
2	Northern Spy..........	1.065	15.49	9.95	3.43	.014	0.19	0.51	.03
3	Northern Spy..........	1.064	15.12	9.73	3.12	.013	0.20	0.49	.04
4	Roxbury Russet.......	1.069	16.46	8.85	5.28	.021	0.23	0.63	.04
5	Roxbury Russet.......	1.072	16.85	9.06	5.46	.020	0.20	0.66	.02
6	Mixed Russet..........	1.074	17.19	9.23	5.78	.023	0.28	0.62	.05
7	Baldwin...............	1.060	14.43	8.57	4.37	.017	0.23	0.59	.04
8	Reinette Pippin.......	1.056	13.50	9.14	2.67	.010	0.21	0.47	.04
9	Mixed fall and winter...	1.065	15.43	9.33	4.26	.016	0.27	0.51	.03
10	Mixed fall and winter...	1.057	13.73	9.23	3.01	.014	0.18	0.41	.03
11	Mixed fall and winter ..	1.060	14.01	7.49	4.33	.020	0.27	0.59	.03
17	Mixed fall and winter...	1.065	15.27	10.34	2.68	.021	0.31	0.41	.00
29	Mixed fall and winter...	1.062	13.97	9.64	3.01	.029	0.27	0.54	.02
	Average of all......	1.064	15.11	9.28	3.85	.018	0.23	0.53	.03

The data in Table I are summarized in the following statement:

(1) *Specific gravity.*—The specific gravity in the different samples of apple juice varied from 1.056 to 1.074 and averaged 1.064.

(2) *Solids.*—The percentage of total solids varied from 13.50 to 17.19 and averaged 15.11.

(3) *Reducing sugars.*—The amount of reducing sugars varied from 7.49 to 10.34 and averaged 9.28 per cent.

(4) *Sucrose.*—The percentage of sucrose varied from 2.67 to 5.78 and averaged 3.85.

(5) *Total sugar.*—The total amount of sugar, equivalent to invert sugar, varied from 11.89 to 15.32 and averaged 13.33 per cent.

(6) *Nitrogen.*—Nitrogen varied in amount from 0.01 to 0.029 per cent. and averaged 0.018 per cent.

(7) *Ash.*—The percentage of ash varied from 0.18 to 0.31 and averaged 0.23.

(8) *Fixed acids.*—The amount of fixed acids, calculated as malic acid, varied from 0.41 to 0.66 per cent. and averaged 0.53 per cent.

(9) *Volatile acids* were practically absent.

(10) *Variations in composition.*—It is noticeable that the composition of apple juice varies considerably. The extent of such variation is still more striking, if we study analyses of apple juice made elsewhere. In Table II, we give the results of analysis of apple juice obtained by others from different varieties of American apples. The results presented in the following table are from work done by C. A. Browne, Jr.,[1] at the Pennsylvania State Agricultural Experiment Station; by J. S. Burd[2] of the Division of Chemistry, United States Department of Agriculture; and by R. J. Davidson,[3] of the Virginia Agricultural Experiment Station. There is also presented for comparison a summary showing the average composition of apple juice investigated by the different workers.

[1]Annual Report of the Pennsylvania State College for 1901–1902, p. 120.

[2]Bulletin No. 136 of the Virginia Agricultural Experiment Station (1902).

[3]Bulletin No. 136 and 143 of the Virginia Agricultural Experiment Station, pp. 94–95 (1902).

TABLE II.—ANALYSES OF APPLE JUICE OF DIFFERENT VARIETIES OF AMERICAN APPLES.

VARIETY OF APPLE.	Specific gravity.	Solids.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Ash.	Fixed acid as malic.	Analyst.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Albemarle (Yel. Newtown) Pippin.	1.062	11.48	6.14	3.10	9.40	——	0.41	Davidson
Albemarle (Yel. Newtown) Pippin.	1.056	14.00	6.62	4.25	10.09	——	0.62	Davidson
American Summer	1.062	16.05	8.50	3.74	12.44	——	0.37	Davidson
Arkansas (Mammoth Black Twig).	1.051	12.05	7.00	3.67	10.86	——	0 41	Davidson
Arkansas (Mammoth Black Twig).	1.056	14.14	7.90	3.35	11.64	——	0.71	Davidson
Baldwin	1.072	16.82	7.97	7.05	15.39	0.26	0.67	Browne
Baldwin	1.055	13.92	5.96	4.91	11.13	——	0.69	Davidson
Baldwin	1.051	13.64	5.40	6.01	11.72	0.25	0.62	Burd
Baltzby	1.046	10.76	5.23	3.35	8.76	——	0.64	Davidson
Baltzby	1.050	13.04	6.40	3.42	10.00	——	0.15	Davidson
Belle de Boskoop	1.062	16.21	6.93	5.29	12.50	——	1.07	Davidson
Belleflower	1.061	14.90	8.54	4.07	12.82	——	0.58	Browne
Ben Davis	1.052	12.77	6.75	3.66	10.60	0.28	0.46	Browne
Ben Davis	1.046	10.69	5.05	1.60	6.74	——	0.44	Davidson
Benoni	1.046	11.73	5.24	4.22	9.68	——	0.48	Davidson
Bonum	1.060	14.23	7.72	3.47	11.37	——	0.37	Davidson
Bonum	1.059	14.93	9.46	1.81	11.30	0.26	0.52	Burd
Buckingham	1.045	11.01	7.00	2.11	9.22	——	0.48	Davidson
Bullock's Pippin	1.053	14.72	6.25	4.84	11.30	0.25	0.42	Burd
Cannon	1.054	14.52	5.32	5.87	11.50	——	0.44	Davidson
Carolina June	1.044	10.99	4.57	3.15	7.99	——	0.66	Davidson
Chenango	1.050	12.61	6.79	2.26	9.17	——	0.40	Davidson
Early Harvest	1.054	13.29	7.11	3.47	11.08	0.28	0.86	Browne
Early Strawberry	1.048	11.81	5.22	4.01	9.44	0.24	0.74	Browne
Emperor Alexander	1.060	13.78	9.24	1.22	10.52	——	0.63	Davidson
Emperor Alexander	1.059	15.27	7.22	3.71	11.12	0.37	0.74	Burd
English Crab	1.053	12.68	6.31	3.14	9.60	——	0.42	Davidson
English Crab	1.057	14.17	8.60	2.85	11.60	——	0.64	Davidson
Eureka	1.057	13.19	7.10	2.76	10.00	——	0.83	Davidson
Eureka	1.056	14.35	7.16	4.23	11.61	0.37	0.93	Burd
Fallawater (Tulpehocken)	1.056	13.94	9.17	2.94	12.26	0.24	0.26	Browne
Fall Orange	1.055	13.31	6.62	3.42	10.22	——	0.54	Davidson
Fall Pippin	1.049	12.22	7.14	3.92	11.27	——	0.58	Davidson
Fanny	1.053	12.84	6.78	4.22	11.22	——	0.51	Davidson
Fanny	1.042	10.97	5.72	2.28	8.12	0.24	0.41	Burd
Gano	1.046	10.16	5.53	2.93	8.60	——	0.41	Davidson
Gano	1.056	13.92	6.96	4.14	11.32	——	0.41	Davidson
Grimes Golden	1.070	18.81	7.33	6.39	14.05	0.30	0.74	Burd
Grimes Golden	1.063	15.39	6.95	5.29	12.52	——	0.60	Davidson
Hyslop Crab	1.065	14.88	6.80	4.78	11.84	——	0.81	Davidson
Jersey Sweet	1.053	13.28	5.61	5.06	10.94	——	0.16	Davidson
Jonathan	1.050	13.18	6.76	2.63	9.52	0.37	0.26	Burd
Jonathan	1.056	14.62	7.00	4.37	11.60	——	0.32	Davidson
Kentucky Cider Crab	1.066	15.42	8.75	3.33	12.25	——	0.71	Davidson
Lankford	1.051	13.42	7.93	2.07	10.10	0.25	0.49	Burd
Lankford	1.054	13.35	7.14	3.53	10.86	——	0.56	Davidson
Lawver	1.049	11.96	8.05	1.76	9.91	——	0.16	Davidson
Lawver	1.057	14.42	8.10	3.01	11.27	——	0.58	Davidson
Limber Twig	1.057	14.11	7.44	3.86	11.50	——	0.62	Davidson
Loy	1.052	11.76	5.43	1.57	7.08	——	0.51	Davidson
Maiden Blush	1.051	12.70	6.34	3.47	9.99	——	0.67	Davidson
Maiden Blush Crab	1.066	16.03	7.85	4.54	12.63	——	0.45	Davidson
Maiden Blush Crab	1.070	18.56	10.00	4.56	14.78	——	0.44	Davidson
Mann	1.061	14.08	7.43	2.77	10.35	——	0.57	Davidson
Missouri Pippin	1.049	12.08	5.57	3.99	9.77	0.31	0.60	Burd
Montreal Beauty Crab	1.045	10.90	5.31	2.64	8.09	——	0.48	Davidson
Mother	1.060	14.77	7.31	4.16	11.69	——	0.37	Davidson
Moulin à Vent	1.061	15.77	7.27	3.54	11.00	——	0.29	Davidson
Nansemond Beauty	1.051	13.18	7.15	2.80	10.09	0.33	0.64	Burd
Nero	1.046	12.00	7.63	1.39	9.09	0.24	0.41	Burd
Nero	1.046	10.61	6.77	1.72	8.58	——	0.36	Davidson
Northern Spy	1.053	11.73	5.36	3.29	8.82	——	0.68	Davidson
Northern Spy	1.052	13.77	6.10	3.50	9.77	0.32	0.69	Burd
Oldenburg	1.047	11.70	5.60	2.20	7.92	——	0.97	Davidson
Peck Pleasant	1.053	14.05	6.18	3.80	10.18	0.24	0.48	Burd
Peck Pleasant	1.054	13.63	6.74	3.79	10.73	——	0.53	Davidson
Peck Pleasant	1.054	12.60	5.32	4.66	10.23	——	0.48	Davidson

TABLE II.—*Continued.*

VARIETY OF APPLE.	Specific gravity.	Solids.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Ash.	Fixed acid as malic.	Analyst.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
Plumb Cider	1.055	15.17	7.12	3.27	10.56	——	0.85	Davidson
Porter	1.055	14.15	6.00	3.07	9.23	——	0.53	Davidson
Queen's Choice Crab	1.060	15.90	6.45	4.80	11.50	——	0.53	Davidson
Ralls	1.052	13.12	7.92	2.62	10.68	——	0.49	Davidson
Red Astrachan	1.052	12.78	6.53	3.45	10.16	0.3	1.15	Browne
Red Siberian Crab	1.070	17.34	9.54	2.17	11.83	——	0.97	Davidson
Ridge Pippin	1.051	11.73	4.69	3.77	8.66	——	0.44	Davidson
Rome Beauty	1.048	11.37	6.24	2.17	8.70	——	0.37	Davidson
Roxbury Russet	1.057	12.87	5.15	5.41	10.84	0.25	0.63	Burd
Roxbury Russet	1.065	16.91	6.74	6.14	13.20	——	0.81	Davidson
Sharp	1.051	11.96	8.09	1.81	10.00	——	0.68	Davidson
Smith Cider	1.062	13.31	8.63	1.24	9.93	——	0.66	Davidson
Smith Cider	1.057	14.44	7.44	3.99	11.64	——	0.71	Davidson
Smith Cider	1.059	13.08	7.77	2.82	10.73	0.37	0.65	Burd
Smokehouse	1.061	15.65	7.92	4.34	12.49	——	0.66	Davidson
Soups of Wine	1.054	12.86	5.42	4.24	9.80	——	0.40	Davidson
Soulard Crab	1.050	12.26	5.99	2.86	9.00	——	0.92	Davidson
Stark	1.058	15.05	9.26	3.85	13.31	——	0.57	Davidson
Summer Rose	1.046	10.30	5.77	2.76	8.68	——	0.60	Davidson
Sweet Vandevere	1.056	12.83	8.39	2.97	11.51	0.28	0.28	Browne
Sweet Bough	1.048	11.87	7.26	2.93	10.34	——	0.10	Browne
Tolman Sweet	1.055	12.42	5.98	3.59	9.76	——	0.20	Davidson
Tolman Sweet	1.055	14.27	7.05	3.62	10.86	——	0.19	Davidson
Tolman Sweet	1.053	14.60	6.33	3.77	10.29	0.28	0.22	Burd
Transcendent Crab	1.069	17.09	7.68	4.00	11.90	——	0.96	Davidson
Via	1.045	11.74	7.14	1.21	8.41	0.24	0.25	Burd
Via	1.044	10.88	7.57	1.31	8.95	——	0.18	Davidson
Walbridge	1.051	11.57	7.94	1.18	9.18	——	0.60	Davidson
Wealthy	1.057	15.26	7.70	3.74	11.64	——	0.66	Davidson
Westfield	1.045	10.87	5.50	3.18	8.85	——	0.12	Davidson
White Winter Pearmain	1.053	12.75	6.91	3.76	10.86	0.28	0.38	Burd
Whitney	1.060	14.16	8.27	2.96	11.39	——	0.40	Davidson
Williams Favorite	1.051	12.89	5.36	4.17	9.75	——	0.40	Davidson
Willow Twig	1.053	12.11	6.87	2.14	9.12	——	0.59	Davidson
Winesap	1.065	16.45	7.39	5.65	13.34	——	0.53	Davidson
World's Wonder	1.052	12.37	7.55	2.53	10.21	0.24	0.60	Burd
Yates	1.052	12.55	6.89	3.28	10.34	0.26	0.45	Burd
Yates	1.052	12.33	6.79	3.05	10.00	——	0.46	Davidson
Yellow Bellflower	1.049	12.46	6.62	2.99	9.77	——	0.54	Davidson
Yellow Newtown	1.055	13.85	6.48	4.38	11.09	——	0.64	Davidson
Yellow Transparent	1.049	11.71	7.66	2.00	9.76	0.27	0.87	Browne
York Imperial	1.050	11.91	7.08	2.89	10.12	——	0.30	Davidson

TABLE III.—SUMMARY OF ANALYSES OF APPLE JUICE.

AVERAGE OF ANALYSES MADE IN	Specific gravity.	Solids.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Ash.	Fixed acid as malic.	No. of analyses of apple juice.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	
New York	1.064	15.11	9.28	3.85	13.33	0.23	0.53	13
Pensylvania	1.056	13.31	7.67	3.61	11.47	0.28	0.58	11
Virginia	1.053	13.31	7.00	3.35	10.41	——	0.52	77
Washington, D. C.	1.054	13.39	6.84	3.48	10.00	0.33	0.51	21
Average of all	1.054	13.52	7.28	3.45	10.91	0.29	0.52	

The constituents of apple juice that are of most interest in connection with the making of vinegar are the sugars, because they furnish the original material for the final production of acetic acid. It is not our purpose to consider in any detail the chemistry of sugars. Under the term "reducing sugars" used in our tables we include two sugars, *dextrose* and *levulose,* which occur in varying proportions. Sucrose is ordinary cane sugar and is present in apple juice in smaller amounts than the reducing sugars. As we shall see later, the value of apple juice for vinegar-making is mainly dependent upon the amount of sug contained in it. In the preceding tables we have seen that the percentage of sugars varies greatly in apple juice, ranging all the way from 6.74 to 15.39. These variations are dependent upon a variety of conditions, among which the following may be mentinoed as the most prominent: Variety of apple, stage of ripeness, soil, climate and culture.

Browne[4] has shown very clearly the changes that occur in the amount of sugars in apples at different stages of ripeness. We give some of his figures:—

TABLE IV.—SUGAR IN BALDWIN APPLE AT DIFFERENT PERIODS.

DATE.	Condition.	Equivalent of total sugar in form of invert sugar.
1899.		Per ct.
August 7	Very green	8.11
September 13	Green	10.72
November 15	Ripe	14.87
December 15	Over-ripe	14.35

From these results it can readily be seen that sugar is present in apples in largest quantity only when they are ripe. The sugar decreases when apples become over-ripe. Therefore, green apples and partly decayed apples contain less sugar and produce less acid in vinegar than apples that are in the proper stage of ripeness.

It is a matter of interest to notice that sweet apples are not necessarily richer in sugars than sour apples. The increase of sweetness, apparent to the taste, is due more to the fact that sweet apples contain less malic acid than sour apples. For

[4]Annual Report of the Pennsylvania Department of Agriculture for 1899, p. 541.

example, the sample of Red Astrachan apple juice contains 10.16 per ct. of sugars and 1.15 per ct. of malic acid, while Tolman Sweet and Sweet Bough contain about the same amount of sugar but only 0.10 to 0.20 per ct. of malic acid. We have noticed the same fact in studying the composition of other fruits, especially strawberries.

THE ALCOHOLIC FERMENTATION OF APPLE JUICE.

When apple juice is left exposed to the air, it is gradually changed, losing its sweet taste and giving off bubbles of gas more or less vigorously. The most prominent change is the conversion of the sugars into alcohol and carbon dioxide gas, as expressed appropriately by the following general equation:—

$$\underset{\text{Sugar}}{C_6H_{12}O_6} = \underset{\text{Alcohol}}{2\,C_2H_6O} + \underset{\text{Carbon Dioxide}}{2\,CO_2}$$

Alcoholic fermentation is caused by a vegetable ferment or enzym which is produced by ordinary yeast. Cells of the yeast plant are so widely distributed that they get into the apple juice abundantly under ordinary conditions.

Theoretically, we should be able to get from 100 parts of sugar about 15 parts of alcohol and 49 parts of carbon dioxide. In actual practice we are not able to obtain this amount of alcohol, because, under the conditions employed, some of the alcohol is lost by evaporation and some is lost by certain changes that accompany alcoholic fermentation. Our work was not conducted in such a way as to determine accurately the amount of alcohol formed in apple juice from a given amount of sugar; but, according to some very satisfactory work on this point done by [5]Browne, we may obtain in the fermentation of apple juice 45 to 47 parts of alcohol from 100 parts of sugar.

In no case did we find alcohol in freshly expressed apple juice, when we used only sound fruit.

MANAGEMENT OF ALCOHOLIC FERMENTATION.

After the juice was pressed from the apples, it was, in the case of our first experiments, including those numbered 1 to 10, strained through linen cheese-cloth and placed in 10-gallon casks. The casks were placed in a cellar, where the temperature ran

[5]Annual Report of the Pennsylvania Department of Agriculture, 1899, p. 556, and 1901, p. 136.

from 45° to 55° F., and kept there five months, from November to April. The bung-holes of the casks were loosely stoppered with cotton. In experiments numbered 11 to 16, the apple juice was allowed to stand in a large vat for two days to settle and was then siphoned into 20-gallon casks, loosely stoppered with cotton. Those numbered 11 to 14 were placed in the cellar, while those numbered 15 and 16 were placed in a boiler-room, where the temperature varied from about 70° to 80° F. In experiments numbered 17 to 28, the apple juice was stored in quart bottles and kept at 55°, 60°, 65°, 70°, and 85° F. In 22, 23 and 24, malic acid was added to the juice. In experiments 25, 26, 27 and 28 yeast was added to the sterilized apple juice, in 28 malic acid being added.

In experiments 29 and 30, some apple juice was stored in the cellar in 10-gallon casks while in experiments 31 to 35, some of the same kind of juice was stored in 5-pint bottles at 55°, 60°, 65°, 70°, 75° and 80° F.

For the details of analytical results obtained in the individual experiments, the reader is referred to the appendix.

The rapidity of the transformation of sugars into alcohol depends upon several conditions, among which may be mentioned (1) length of time, (2) temperature and (3) addition of yeast.

Relation of time to formation of alcohol.—The data presented in the following table represent the averages of results obtained with the first ten samples of apple juice given in Table I:

TABLE V.—RELATION OF TIME TO ALCOHOLIC FERMENTATION OF APPLE JUICE.

AGE.	Specific gravity.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Alcohol by wt.
		Per ct.	Per ct.	Per ct.	Per ct.
Fresh	1.0640	9.31	4.01	13.53	0.00
1 month	1.0634	9.02	3.35	12.55	0.11
2 months	1.0377	7.16	1.06	8.28	2.77
3 months	1.0123	3.97	0.27	4.27	4.68
4 months	1.0064	2.17	0.12	2.29	5.79
5 months	0.9998	0.72	0.05	0.77	6.73
6 months	0.9990	0.29	0.03	0.32	6.81
7 months	0.9986	0.20	0.03	0.23	6.79

In connection with the data in this table, attention is called to the following points:

(1) The sucrose disappeared more rapidly than the reducing sugars. The former had been practically all changed in five months, while the latter were not completely gone in seven months. It should be stated here that sucrose as such does not undergo fermentation but it must first be changed into dextrose and levulose. This change is affected by an enzym which exists in yeast. The dextrose and levulose thus formed from sucrose are readily acted upon by the alcholic-producing ferment of the yeast.

Taking the total amount of sugar in the fresh apple juice, we find that it disappeared at a rate expressed by the following figures:

In 1 month,	7.1 per cent.	In 5 months	94.3 per cent.
In 2 months,	38.7 per cent.	In 6 months,	97.6 per cent.
In 3 months,	68.4 per cent.	In 7 months,	98.3 per cent.
In 4 months,	81.0 per cent.		

Thus, we see, a large proportion of the sugar had been changed by fermentation in five months under the given conditions.

(2) The alcohol increased quite rapidly after the first month, and approximately in proportion to the amount of sugar that disappeared. The amount of alcohol reached its highest point at the end of six months, when the sugar had practically all gone.

(3) The specific gravity of the fermenting apple juice decreased as the amount of sugar decreased and the amount of alcohol increased, going from 1.064 in the fresh apple juice to 0.9986 at the end of seven months.

Influence of temperature upon the alcoholic fermentation of apple juice.—Samples of cider were placed in rooms, the temperature in each of which is kept practically constant. The temperatures used were 55°, 60°, 65°, 70° and 85° F. (experiments numbered 17, 18, 19, 20 and 21). In other experiments, casks of cider were placed in a celler (experiments 11, 12, 13, 14), the temperatures of which during the time of study varied from about 45° to 55° F. while other casks were placed in a room near a steam boiler, the temperature here varying from about 70° to 80° F. (experiments 15 and 16). The following table contains the results given at the time when the sugar had nearly all disappeared in most of the ciders:

Table VI.—Percentage of Alcohol Formed in Apple Juice at Different Temperatures.

Age When Analyzed.	Temperature.	Specific gravity.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Alcohol by wt.
	Degree F.		Per ct.	Per ct.	Per ct.	Per ct.
Fresh	——	1.0654	10.34	2.68	13.16	0.00
3 months	55	1.0182	2.40	0.00	2.40	2.24
3 months	60	1.0016	0.24	0.05	0.29	4.82
3 months	65	1.0030	0.27	0.03	0.30	4.53
3 months	70	0.9978	0.20	0.03	0.23	6.41
3 months	85	0.9972	0.14	0.03	0.17	6.66
Fresh	——	1.060	7.49	4.33	12.05	0.00
4 months	Cellar	1.0021	0.49	0.01	——	5.53
4 months	Boiler room	1.0006	0.24	0.00	——	5.80

The results embodied in this table indicate that within the limits of temperature employed, the alcoholic fermentation proceeds more rapidly at the higher temperatures.

Influence of adding yeast to apple juice upon alcoholic fermentation.—A pure culture of yeast was added to the bottles of sterilized apple juice used in experiments 25, 26 and 27 and the bottles were kept at 55°, 70° and 85° F. The following table gives the results at the different temperatures as compared with experiments containing no added yeast culture:

Table VII.—Percentage of Alcohol Formed in Apple Juice When Yeast is Added.

Age When Analyzed.	Yeast added.	Temperature.	Specific gravity.	Reducing sugars.	Sucrose.	Equivalent of total sugar in form of invert sugar.	Alcohol by wt.
Months.		Degrees F.		Per ct.	Per ct.	Per ct.	Per ct.
1	Added	55°	1.0102	1.93	0.08	2.01	6.25
1	Not added	45°–55°	1.0634	9.02	3.35	12.55	0.11
1	Added	70°	1.0011	0.31	0.10	0.41	7.25
1	Added	85°	1.0024	0.38	0.01	0.39	6.86
3	Added	55°	1.0006	0.31	0.00	0.31	7.28
3	Not added	45°–55°	1.0213	3.97	0.27	4.27	4.68
3	Added	70°	1.0005	0.24	0.00	0.24	6.10
3	Not added	70°–80°	1.0085	0.40	0.20	0.61	5.78
3	Added	85°	1.0025	0.36	0.00	0.36	6.73

While the results are not strictly comparable in every respect, owing to variation in some of the details of the experiments, they serve to show that the addition of yeast resulted in much more rapid formation of alcohol. The time of the alcohol fermentation can readily be reduced one-half or more by the addition of yeast, especially when the cider is kept at a temperature of 65° to 70° F. The use of any form of commercial yeast, if sufficiently fresh, will probably be found to give good results.

THE ACETIC FERMENTATION OF CIDER.

The object of the maker of cider vinegar is the production of acetic acid, and this is accomplished by means of the fermentation of alcohol that has been formed from sugar. The organisms that change alcohol into acetic acid are different from those that change sugar into alcohol. There are several varieties of acetic bacteria capable of causing the acetic fermentation of alcohol. For the effective conversion of cider into vinegar, there are needed, (1) the acetic bacteria, (2) an abundant supply of air, (3) a temperature between 65° and 85° F. There is commonly noticed in vinegar a very elastic, slimy, tough, transparent skin of a yellowish-white color; this skin is commonly known as "mother" of vinegar. This appears to be formed by the growth of the acetic bacteria on the surface of the liquid. When one skin has formed, it settles sooner or later and in its place another is formed and this formation and replacement continue as long as air is supplied under favorable temperature conditions.

The chief chemical change that takes place in the acetic fermentation of alcohol is the combination of oxygen with alcohol, which may be represented thus, though the real change is more complicated:—

$$\underset{\text{Alcohol}}{C_2H_6O} + \underset{\text{Oxygen}}{O_2} = \underset{\text{Acetic acid}}{C_2H_4O_2} + \underset{\text{Water}}{H_2O}$$

Theoretically, we should obtain from 100 parts of alcohol about 130 parts of acetic acid, but for various reasons the actual yield is probably nearer 120 or lower.

MANAGEMENT OF ACETIC FERMENTATION.

In our work, we allowed the cider to remain in the casks and bottles in which the alcoholic fermentation had taken place. We will first give the general averages of the results obtained with the first 10 ciders given in Table I. We shall consider the influence of various factors upon the acetic fermentation such as time, temperature, the addition of vinegar and freedom from sediment.

Relation of time to the acetic fermentation of cider.—The following table gives the average results furnished by 10 ciders in relation to the formation of acetic acid from alcohol; the results commence with the eighth month from the time the apple juice was pressed from the apples, since at this time sugar had disappeared and the amount of alcohol was at about its maximum:

Table VIII.—Relation of Time to Acetic Fermentation of Alcohol in Cider.

Age.	Specific gravity.	Alcohol.	Volatile acid as acetic.	Fixed acid as malic.	Total acid.
Months.		Per ct.	Per ct.	Per ct.	Per ct.
8	0.9979	6.49	0.40	0.13	0.53
9	0.9984	6.15	0.59	0.10	0.69
10	0.9993	5.67	0.90	0.06	0.96
14	1.0045	4.22	2.57	0.04	2.61
15	1.0048	4.11	2.59	0.03	2.62
21	1.0125	2.35	4.99	0.03	5.02
24	1.0185	0.88	7.01	0.03	7.04
27	1.0187	0.64	7.07	0.02	7.09
29	1.0194	——	7.37	0.02	7.39
33	1.0252	0.18	8.38	0.02	8.40
36	1.0249	0.00	8.83	0.02	8.85
44	——	0.00	9.00	0.01	9.01

A study of the data in this table suggests the following statements: (1) The conversion of alcohol into acetic acid took place slowly during the first three months after the alcohol had reached its maximum, that is, during the 8th, 9th and 10th months after the apple juice was pressed from the apples. From the 10th to the 14th month, the change progressed more rapidly and was practically completed at the end of 24 months.

(2) Even after the disappearance of alcohol, the acid appeared to increase for many months. This was due to the evaporation of water from the vinegar cask, the remaining liquid becoming more concentrated. We have one instance (experiment 15) where the vinegar was stored in a warm place, the bung-hole of the cask being lightly plugged with cotton, and evaporation took place to such an extent that in about six years the vinegar contained over 20 per ct. of acetic acid.

(3) Our work was not carried on in such a way as to show the amount of acetic acid formed by the alcohol present in the liquid. As we have previously stated, theoretical considerations call for the production of 130 parts of acetic acid from 100 parts of alcohol, but the yield in actual practice has been found lower, probably below 120.

(4) The fixed acid, which we have regarded as consisting chiefly of malic acid, decreased in amount as the cider became older. To this feature, we shall call special attention later.

(5) The specific gravity increased as the alcohol was converted into acetic acid, going from 0.9979 to about 1.02, when the alcohol had disappeared. A portion of the increase during the later months of the experiment was due to some evaporation of water.

The influence of temperature upon the acetic fermentation of cider.—When at the end of about six months the alcoholic fermentation had been completed in experiments numbered 1 to 10, five of the casks were left in the cellar, and the other five were transferred to a room where the temperature was considerably higher. In the cellar the extremes of temperature during the year were 45° to 65° F., while in the other place the variation was between 50° to 90° F. The following table gives the averages of the results secured under these two different conditions of temperature. It was designed to have the condition of the casks kept in the cellar approximate as nearly as possible the conditions commonly observed by farmers in making cider vinegar.

TABLE IX.—INFLUENCE OF TEMPERATURE UPON FORMATION OF ACID FROM ALCOHOL.

AGE.	PERCENTAGE OF ALCOHOL IN CIDER KEPT.		PERCENTAGE OF TOTAL ACID IN CIDER KEPT.	
	At lower temperature.	At higher temperature.	At lower temperature.	At higher temperature.
Months.	Per ct.	Per ct.	Per ct.	Per ct.
7	6.83	6.74	0.61	0.56
8	6.46	6.52	0.55	0.51
9	6.00	6.30	0.69	0.69
10	5.54	5.79	0.79	1.13
14	4.85	3.58	1.40	3.82
21	3.46	2.24	2.77	7.27
24	1.68	0.33	4.95	9.18
27	1.29	0.00	—	— 2
29	0.00	0.00	5.55	9.23
33	0.00	0.00	6.48	10.30
36	0.00	0.00	6.88	10.84
44	0.00	0.00	7.01	11.01

A study of the data in this table indicates that the acetic fermentation of alcohol was very slow in its action during the first three months after the alcoholic fermentation was completed. In these experiments the differences of temperature that existed did not appear to exert much influence upon the acetic fermentation for three months. We notice that then alcohol decreases and acid increases more rapidly at the higher temperature. Between the 24th and 27th months, the alcohol disappeared entirely at the higher temperature and this did not occur at the lower temperature until sometime between the 27th and 29th months. After the alcohol disappeared, the percentage of acid continued to increase at both temperatures but more noticeably at the higher temperature. This was due, not to additional formation of acid, but to concentration of the acid already formed, as the result of the evaporation of water from the casks, the bung-holes being open except for a loose plug of cotton.

In another set of experiments, we placed four casks of apple juice in the same cellar previously referred to and two casks in a warm boiler room. The results are given in the following table:

Table X.—Influence of Temperature upon Formation of Acid from Alcohol.

Age.	Percentage of Alcohol in Cider Kept.		Percentage of Total Acid in Cider Kept.	
	At lower temperature.	At higher temperature.	At lower temperature.	At higher temperature.
Months.	Per ct.	Per ct.	Per ct.	Per ct.
10	5.76	5.96	0.53	0.45
12	5.80	5.45	0.40	0.85
15½	5.60	4.55	0.42	1.95
18	5.36	3.66	0.47	3.65
22	4.19	2.03	0.58	5.45
26	2.95	1.82	1.92	5.92
33	1.00	0.97	3.62	8.14

These data show a greater difference in the influence of temperature than those in the preceding table, since the difference in temperatures was considerably greater. The higher temperature favored the more rapid formation of acid from alcohol.

Another set of experiments was carried on, in which the apple juice was stored in quart bottles and kept at definite temperatures, as follows:—55°, 60°, 65°, 70°, 85° F. The results of this work are given in the following table, only the amounts of total acid being given:

TABLE XI.—INFLUENCE OF TEMPERATURE UPON FORMATION OF ACID.

AGE.	Percentage of total acid in cider kept at temperature of				
	55° F.	60° F.	65° F.	70° F.	85° F.
Months.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
3	2.77	1.46	2.29	0.78	0.28
6	3.63	4.32	7.03	4.99	0.35
9	4.45	4.81	7.67	7.05	3.45
14	3.03	5.41	6.88	7.77	4.23
15	2.73	5.32	7.02	7.73	4.39
21	1.43	4.87	6.94	7.79	6.53
60	0.00	0.00	8.86	8.46	6.77

A study of the data in Table XI suggests the following statements:

(1) The highest amounts of acetic acid were obtained when the fermentation was carried on at 65° and 70° F. and this was true at any given time after the third month.

(2) At 85° F. the fermentation was slowest in starting but gave a continuously increasing amount of acid for 21 months; at this time the amount of acid formed was higher than at 55° or 60° F.

(3) While acetic fermentation started quite promptly at 55° F. it reached its maximum in nine months and this was considerably lower than the maximum reached at the other temperatures. After the ninth month, the acid decreased continuously, evidently undergoing a destructive fermentation, and finally disappeared altogether. At 60° F. there was something of this loss of acid but not so marked as at 55° F. during 21 months but later the acid all disappeared. This loss did not occur at the other temperatures during the 21 months in which the work was continued.

(4) So far as the results furnish evidence we can look for the most satisfactory results of acetic fermentation, all things considered, at temperatures between 65° and 75° F.

The influence of adding vinegar to cider upon the acetic fermentation.—When at the end of eight months the alcoholic fermentation was complete, we added to each of several 10-gallon casks of cider one pint of cider vinegar. Three sets of experiments were made, comparing the addition of vinegar with its omission, the results of which are given below. In the case of numbers 4, 5, 7 and 8, the temperature was lower than in 9 and 10, the former being stored in the cellar.

TABLE XII.—INFLUENCE OF ADDING VINEGAR UPON ACETIC FERMENTATION.

AGE.	PERCENTAGE OF ACID.		PERCENTAGE OF ACID.		PERCENTAGE OF ACID.	
	(No. 4) no vinegar added.	(No. 5) vinegar added.	(No. 10) no vinegar added.	(No. 9) vinegar added.	(No. 8) no vinegar added.	(No. 7) vinegar added.
Months.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
8	0.45	0.42	0.65	0.64	0.40	0.61
9	0.37	0.44	0.83	1.19	0.39	1.06
10	0.39	0.40	1.60	1.86	0.64	1.38
15	0.42	0.41	3.59	4.22	1.05	2.68
21	0.37	0.69	7.09	7.37	1.04	5.04
24	0.80	5.16	8.53	9.54	3.76	6.66
29	1.42	6.86	8.80	10.09	5.70	6.83
33	4.24	7.53	9.96	11.74	6.16	6.90
36	6.59	7.08	10.66	13.25	5.97	7.01

These results indicate in every case that the acetic acid fermentation took place more rapidly when vinegar was added. In the case of No. 4, where the cider was stored in a cool cellar, acetic fermentation did not fairly start until the 24th month after the juice was pressed from the apples, or 16 months after the alcoholic fermentation ceased; and the cider did not become marketable vinegar until about ten months later. In the case of No. 5, the parallel experiment, in which vinegar was added, the acetic fermentation was slow in starting, but was under way 15 months after the addition of vinegar and the product was marketable within less than three months after, or nearly a year sooner than in case of No. 4. The acetic fermentation started more promptly in the other ciders under experiment, but in each case was hastened by the addition of vinegar. In the case of Nos. 9 and 10, which were kept at a higher temperature, there was less difference produced by the addition of vinegar than in the case of the ciders stored in the cool cellar.

The addition of cider vinegar of good quality and not too old is a practical inoculation of the cider with the organisms of acetic fermentation and is comparable to the addition of a sour-milk "starter" to cream in order to produce ripening, that is, formation of lactic acid. The practice of adding "mother" of vinegar to cider is based upon the same explanation. Effort should be made to have some "mother" in the vinegar added.

In another experiment (15), vinegar was added when the apple juice had been fermenting two months, and the alcoholic fermentation was still incomplete. In this case, the acetic ferment thus added appeared to exercise no influence upon the formation of acid.

The influence of separating the clear portion of cider from sediment upon the acetic fermentation.—In the experiments numbered 1 to 10, a study was made of the effect of separating the clear portion of the cider from the sediment after the alcoholic fermentation was completed and in some cases the clear liquid was siphoned off and only this clear portion used for the acetic fermentation. Even though the fresh apple juice was in all cases carefully strained through linen cheese cloth, much insoluble matter remained, which settled to the bottom of the cask during the alcohol fermentation. In the case of the strained and siphoned ciders the casks were cleaned before replacing the ciders.

The ciders numbered 1 and 3 were strained, those numbered 2, 4, 5 and 6 were left undisturbed, while in 7, 8, 9 and 10 the clear portion was siphoned off and this alone used. The results are presented in the following table:

TABLE XIII.—PERCENTAGE OF ACID IN CIDER VINEGAR WHEN STRAINED AND UNSTRAINED.

AGE.	Stored in Cool Cellars.			Stored in Warm Room.		
	Siphoned.	Strained.	Not strained.	Siphoned.	Strained.	Not strained.
Months.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
6	0.57	0.56	0.65	0.55	0.55	0.56
9	0.39	1.18	0.37	0.83	0.62	0.38
10	0.64	1.15	0.39	1.60	1.05	0.70
14	1.05	2.36	0.42	3.69	4.01	4.45
21	3.76	3.95	0.37	7.09	7.03	9.24
24	5.70	6.15	0.80	8.53	9.08	—
27	6.05	6.41	1.48	7.57	—	9.58
29	6.16	6.49	1.42	8.80	8.73	—
33	5.97	7.78	4.24	9.96	10.00	—
44	6.15	7.97	6.83	10.51	11.05	9.82

While these few results are not at all conclusive, they suggest that at low temperatures the clear liquids form acid more quickly, while at higher temperatures there is little practical difference. In no case did any of these vinegars show signs of deterioration during the 44 months of the experiment. In these particular cases, the sediment did not appear to carry forms of living organisms that prevented the ultimate formation of acid in good quantities.

LOSS OF ACETIC ACID IN VINEGAR ON STANDING.

Reference has been made to the fact that cider vinegar occasionally suffers deterioration on standing a long time and loses more or less completely its sourness. Some cases have been brought to our attention by farmers in which all acetic acid had disappeared and the liquid was no longer vinegar. This condition is well illustrated in the experiments numbered 17, 18, 22, 30, 31, 32, 33, 34 and 35. In the set of experiments started in 1900, including those numbered 30 to 35, all lost their acid and in most cases completely, while in some the reaction was actually alkaline.

This disappearance of acetic acid in vinegar is due to forms of fermentation that decompose the acetic acid, changing it into other substances, largely water and carbon dioxide. Several different organisms are known that decompose dilute acetic acid. Among these Pasteur showed that the acetic acid bacteria themselves, after changing alcohol into acetic acid, attack the acetic acid found and destroy it, especially when there is a free access of air to the liquid. Browne[6] made a study of a sample of deteriorated vinegar and found the injurious organism to be *Bacterium xylinum*, which, while an acetic-acid-forming bacterium, was different in this case from the bacteria that had produced the acetic acid.

Bertrand[7] attributes the inoculation of *Bacterium xylinum* to the small vinegar flies that are so common in places where fermentation of fruit juices is taking place.

In our work it was noticed in most cases, where the vinegar had lost its acid, that the "mother" was black and the liquid itself abnormally dark in color. In experiments 17, 18 and 22,

[6] Annual Report of the Pennsylvania State College for 1901–1902, p. 156.

[7] Comptes Rendus, 122: 900.

the temperature was 55° and 60° F.; in all parallel experiments of this series (17 to 29) at higher temperatures, little or no loss was noticed in most cases. In these experiments, the mouth of the bottle used in each case was closed by the loose insertion of a rubber stopper. In the set of experiments numbered 30 to 35, the mouths of the bottles were quite large and were not closed at all, practically, simply having a loose plug of cotton inserted. This condition favored ready access of air and probably accounts in large part for the general deterioration observed in this set of experiments.

This destructive change in vinegar can easily be prevented, when once vinegar has been made. The acetic organisms all require oxygen for their existence and their activity can be prevented by excluding air. In actual practice, it is advised, when once the vinegar has reached a sufficient degree of acidity (4.5 per ct. or more of acetic acid) to draw off or filter the vinegar and then place in a clean barrel, filling it as full as possible and putting the bung in tight.

VARIATIONS IN VINEGAR MADE UNDER UNIFORM CONDITIONS.

In experiments 17 to 21 and 25 to 27, the material was stored in each case in several quart bottles and in experiments 30 to 35 we used five pint bottles in each case. It was noticed quite early in the work that the material in different bottles kept under like conditions was not behaving uniformly and the analyses given represent composite samples taken from the different bottles kept under the same conditions. At the close of the work, analysis was made of the material in each individual bottle and these are given in full in the appendix. We desire to use some of these data here to indicate how it is possible for quite different results to be obtained from different portions of the same material kept under the same uniform conditions of temperature and general treatment. Experiment 17 furnishes the most striking illustration. In this case there were used four bottles, each holding a quart. The analyses were made when the vinegar was about five years old. At the beginning of the experiment portions of the same apple juice were placed in these bottles and these stood side by side under the same general conditions.

TABLE XIV.—VARIATIONS IN COMPOSITION OF VINEGAR UNDER UNIFORM CONDITIONS.

BOTTLE.	Age when analyzed.	Specific gravity.	Solids.	Acetic acid.	Fixed acid.
			Per ct.	Per ct.	Per ct.
a..................	5 years.....	1.0139	1.70	5.74	0.00
b..................	5 years.....	1.0122	1.58	5.44	0.00
c..................	5 years.....	1.0095	1.70	2.10	0.00
d..................	5 years.....	1.0029	0.60	alkaline	0.00

In bottles a and b, the differences are only what might ordinarily be expected, but in c the acetic acid has dropped to only about 2 per ct. while in d the solids had been greatly reduced and the acetic acid had entirely disappeared, and not that alone, but the liquid was actually alkaline. The liquid in c was very dark colored and the "mother" black, showing evidence of acetic destroying ferment. These differences are readily explained as being due to the activity of different ferments in the different bottles, but in the absence of special study of the organisms, we are unable to say what specific organisms were present. It is probable that the stopper in bottle d was so loosely inserted as to admit air freely.

THE BEHAVIOR OF THE MALIC ACID OF APPLE JUICE DURING THE FERMENTATION PROCESSES.

Malic acid in the form of free acid or acid salts in the juice of different varieties of apples varies greatly in amount. In the analyses published in Table II, it averages a little over 0.5 per ct. varying all the way from 0.1 per ct. in the Sweet Bough to 1.15 per ct. in the Red Astrachan. In the juice of the different varieties used in our experiments the malic acid varied from 0.41 to 0.66 per ct., averaging 0.53 per ct. A special examination of the juice of several varieties of apples showed practically no neutral salts of malic acid. Early in our work we noticed that the amount of malic acid decreased when the apple juice was allowed to ferment, and the diminution continued until the malic acid nearly disappeared. The work of Browne[8] shows similar results. In the following table we present our results in detail:

[8]Annual Report of the Pennsylvania Department of Agriculture, 1901, pp. 128–9.

TABLE XV.—PERCENTAGE OF FIXED ACID AS MALIC ACID IN APPLE JUICE AT DIFFERENT PERIODS OF FERMENTATION.

Number of sample.	Fresh.	1 mo.	6 mos.	7 mos.	8 mos.	9 mos.	10 mos.	15 mos.	24 mos.	72 mos.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
1	0.52	0.50	0.46	0.42	0.44	0.24	0.02	0.02	0.01	——
2	0.51	0.48	0.39	0.39	0.09	0.09	0.04	0.01	0.02	——
3	0.49	0.48	0.36	0.34	0.11	0.08	0.03	0.01	0.02	——
4	0.63	0.63	0.41	0.41	0.18	0.09	0.05	0.10	0.07	——
5	0.66	0.65	0.48	0.49	0.10	0.10	0.08	0.10	0.01	——
6	0.62	0.62	0.47	0.47	0.07	0.09	0.10	0.02	0.03	0.04
7	0.59	0.53	0.37	0.27	0.06	0.06	0.05	0.03	0.01	——
8	0.47	0.47	0.41	0.29	0.08	0.07	0.06	0.02	0.01	——
9	0.51	0.50	0.40	0.32	0.11	0.09	0.06	0.05	0.05	——
10	0.41	0.39	0.35	0.13	0.06	0.07	0.09	0.03	0.03	——
11	0.59	——	0.40	——	——	——	0.09	0.10	0.02	0.01
12	0.59	——	0.41	——	——	——	——	0.11	0.02	0.00
13	0.59	——	0.37	——	——	——	0.18	0.14	0.02	0.00
14	0.59	——	0.43	——	——	——	——	0.16	0.05	——
15	0.59	——	0.41	——	——	——	——	0.09	0.01	——
16	0.59	——	0.39	——	——	——	0.16	0.02	0.01	——
17	0.41	——	0.16	——	——	0.16	0.13	——	——	——
Average	0.55	0.53	0.39	0.35	0.13	0.10	0.08	0.06	0.02	——

In studying the data contained in this table, we notice the following points:

(1) In most cases very little change in the amount of fixed acid occurs during the first month.

(2) Nearly one-third of the fixed acid disappeared in six months; between the sixth and seventh months some more malic acid disappeared, but between the seventh and eighth months, in most cases, the decrease of fixed acid was very marked.

(3) The period when the malic acid decreased most rapidly was after the alcoholic fermentation had been completed and before the acetic fermentation had become very active.

(4) As a rule, when the cider had become good vinegar, there remained only a trace of fixed acid. In the case of some old vinegars, all fixed acid disappeared.

The decrease of malic acid under these circumstances is undoubtedly the result of the action of some bacterial ferment. It is[9] well known that malic acid and some of its salts undergo destructive fermentation, but, so far as we have been able to learn, no one has worked out the details of this phenomenon in relation to cider vinegar. Seifert[10] has shown that the decrease

[9] Emmerling. Die Zersetzung Stickstofffrier organischer Substanzen durch Bakterein, pp. 128–9 (1902).

[10] Bied, Centr., 33: 488 (1904).

of acidity in wine is caused by special bacteria, especially *Micrococus malolacticus,* which converts malic acid into lactic acid and a very small amount of volatile acids, while other acids such as lactic and acetic are not attached. In alcoholic solutions, a production of acetic acid may take place. When malic acid and sugar are present, an increase in acidity takes place, more acid being produced than last. Yeast acts comparatively slightly on malic acid. Acetic acid bacteria may also decompose malic acid.

CONDITIONS AFFECTING MALIC ACID IN CIDER VINEGAR.

The presence of malic acid or its salts in cider vinegar is a question of importance in relation to determining its purity and to this phase we will give attention later.

(1) *Effect of fermentation upon malic acid added to apple juice.*—In order to study farther the disappearance of malic acid in apple juice, some special experiments (22, 23, 24, 28) were prepared. To some apple juice, containing 0.41 per ct. of malic acid, we added enough artificial malic acid to bring the amount to 1.02 per ct. Bottles of this apple juice containing malic acid were kept at different temperatures along with bottles of the same apple juice containing only malic acid normally present. In experiment 28 the apple juice had been sterilized and yeast added. In the following table we present the results of these experiments, carried on at 55°, 70° and 85° F.:

TABLE XVI.—EFFECT OF FERMENTATION UPON MALIC ACID ADDED TO APPLE JUICE.

AGE.	PERCENTAGE OF MALIC ACID IN APPLE JUICE AND VINEGAR KEPT AT							
	55° F.		70° F.		85° F.		55° F. (Sterilized)	
	Normal.	Malic acid added.	Normal.	Malic acid added.	Normal.	Malic acid. added.	Normal.	Malic acid added.
Months.	Exp. 17.	Exp. 22.	Exp. 20.	Exp. 23.	Exp. 21.	Exp. 24.	Exp. 25.	Exp. 28
Fresh	0.41	1.02	0.41	1.02	0.41	1.02	0.41	1.02
3	0.20	0.69	0.08	0.46	0.10	0.54	0.47	0.63
6	0.16	0.61	0.03	0.36	0.10	0.54	0.44	0.39
9	0.16	0.49	0.01	0.32	0.05	0.46	0.41	0.31
15	0.13	0.30	0.01	0.28	0.01	0.38	0.40	0.28
21	——	0.21	0.01	0.27	0.01	0.38	0.26	0.30
60	0.00	0.00	0.00	0.21	0.00	0.35	0.17	0.21

These results show that the added malic acid underwent fermentation to a marked extent. The disappearance of added malic acid was complete at 55° F., while at the higher temperatures it was not complete.

(2) *Effect of temperature upon destructive fermentation of malic acid.*—The effect of temperature upon the disappearance of malic acid can be studied in connection with the data presented in the preceding and following tables:

TABLE XVII.—RELATION OF TEMPERATURE TO THE DESTRUCTIVE FERMENTATION OF MALIC ACID.

AGE.	PERCENTAGE OF MALIC ACID IN APPLE JUICE AND VINEGAR KEPT AT					
	55° F.	60° F.	65° F.	70° F.	75° F.	80° F.
Months.	Exp. 31.	Exp. 32.	Exp. 33.	Exp. 34.	Exp. 35.	Exp. 36.
Fresh.........	0.54	0.54	0.54	0.54	0.54	0.54
2............	0.43	0.02	0.03	0.01	0.01	0.01
3............	0.34	0.01	0.01	0.01	0.01	0.01
7............	0.32	0.01	0.01	0.01	0.01	0.01
9............	0.30	0.01	0.01	0.01	0.01	0.01
48............	0.00	0.00	0.00	0.00	0.00	0.00

The general tendency appears to be a less rapid loss of malic acid at lower temperatures. At 70° F. and above, the loss was uniform.

(3) *Effect of sterilizing apple juice upon decrease of malic acid.*—In experiments 25, 26 and 27 the apple juice was sterilized. Parallel experiments with normal material were carried on at the same time. The tabulated results are given below. The general tendency, as shown by these results, is a less rapid and complete destruction of malic acid in sterilized material. In 60 months, malic acid had disappeared entirely in those experiments where there had been no sterilization, but was still present in marked amounts in the sterilized samples. Sterilization must have destroyed the organisms responsible for the destruction of malic acid and apparently after this the conditions were not favorable for their growth.

TABLE XVIII.—EFFECT OF STERILIZATION UPON DECREASE OF MALIC ACID.

AGE.	Percentage of Malic Acid in Apple Juice and Vinegar Kept at					
	55° F.		70° F.		85° F.	
	Normal.	Sterilized.	Normal.	Sterilized.	Normal.	Sterilized.
Months.	Exp. 17.	Exp. 25.	Exp. 20.	Exp. 26.	Exp. 21.	Exp. 27.
Fresh.........	0.41	0.51	0.41	0.51	0.41	0.51
3............	0.20	0.47	0.08	0.44	0.10	0.46
6–7..........	0.16	0.44	0.03	0.39	0.10	0.45
9–11.........	0.16	0.41	0.01	0.29	0.05	0.43
12–14.........	0.13	0.40	0.01	0.27	0.01	0.43
18–21.........	——	0.26	0.01	0.23	0.01	0.38
60............	0.00	0.17	0.00	0.32	0.00	0.35

THE RELATION OF MALIC ACID TO THE IDENTIFICATION OF PURE CIDER VINEGAR.

A common test for the identification of cider vinegar has been the formation of a white precipitate on addition of lead acetate. The formation of the precipitate is based upon the assumed presence of malic acid or malates in the sample tested. It is supposed that any vinegar made from apple juice contains malic acid, and that absence of malic acid, as indicated by no precipitate with lead acetate, is regarded as a proof that the vinegar is from sources other than apples. This test has recently been fully discussed by Leach and Lythgoe,[11] together with some modifications.

In all of the vinegars made by us, we were able to get a white precipitate with lead acetate, even when no malic acid or malates was present. We are making a more detailed study of the relation of malic acid and malates to cider vinegar.

THE SOLIDS OF APPLE JUICE AND CIDER VINEGAR.

The methods employed by us in determining the amount of solids was to heat about five grams of liquid on about 20 grams of pure quartz sand in a steam bath for six to eight hours. The results are given in part in the following table. For full details, see the appendix:

[11] Am. Chem. Soc. 26:378 (1904).

TABLE XVIII.—PERCENTAGES OF SOLIDS IN APPLE JUICE AND CIDER VINEGAR.

No.	Fresh.	3 mos.	5 to 7 mos.	9 to 12 mos.	15 to 18 mos.	21 to 24 mos.	33 mos.	44 to 48 mos.	60 mos.	72 to 80 mos.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
1	15.24	7.12	2.25	2.15	1.53	1.58	1.63	1.60	—	—
2	15.49	6.19	2.47	2.29	1.74	1.75	1.85	1.76	—	—
3	15.12	5.60	2.37	2.27	1.94	2.01	2.01	2.18	—	—
4	16.46	5.19	3.14	2.95	2.53	2.29	2.12	1.96	—	—
5	16.85	8.42	3.25	2.95	2.43	2.42	2.02	2.01	—	—
6	17.19	9.11	3.55	3.15	2.80	2.87	3.19	3.30	—	5.86
7	14.43	7.05	2.45	2.29	1.81	1.94	1.74	1.88	—	—
8	13.50	7.37	2.54	2.32	1.70	1.65	1.49	1.55	—	—
9	15.43	3.89	2.69	2.73	2.37	2.86	3.54	3.95	—	—
10	13.73	4.26	2.15	2.06	1.86	2.20	2.32	2.17	—	—
11	14.01	3.64	2.80	2.26	1.75	1.56	1.47	—	—	2.33
12	14.01	2.86	2.35	2.24	1.65	1.51	1.23	—	—	1.97
13	14.01	2.91	2.39	1.76	1.64	1.40	1.31	—	—	2.25
14	14.01	3.33	2.81	2.66	1.68	1.50	1.24	—	—	—
15	14.01	2.92	2.58	2.40	1.68	1.47	1.72	—	—	7.45
16	14.01	2.77	2.36	2.24	1.79	1.64	2.14	—	—	—
17	15.27	3.80	3.26	2.84	2.31	2.10	—	—	0.73	—
18	15.27	1.77	1.61	1.58	1.41	1.45	—	—	1.70	—
19	15.27	1.63	1.51	1.49	1.33	1.45	—	—	1.71	—
20	15.27	1.66	1.62	1.54	1.58	1.61	—	—	1.79	—
21	15.27	1.65	1.69	1.78	1.47	1.45	—	—	2.02	—
22	15.88	2.27	2.21	2.09	1.84	2.00	—	—	0.60	—
23	15.88	2.00	1.97	1.87	1.61	1.65	—	—	1.78	—
24	15.88	2.27	2.21	2.09	1.84	2.00	—	—	2.15	—
25	15.96	2.96	2.92	2.52	2.53	—	—	—	3.01	—
26	15.96	2.90	2.83	2.32	2.30	—	—	—	2.71	—
27	15.96	3.29	3.25	2.84	2.64	—	—	—	3.72	—
28	16.57	2.12	1.95	1.68	1.86	—	—	—	2.53	—
29	13.97	1.89	—	1.51	—	—	—	1.98	—	—
30	13.97	1.85	—	1.51	—	—	—	2.08	—	—
31	13.97	1.79	1.71	1.51	—	—	—	1.12	—	—
32	13.97	1.30	1.29	1.30	—	—	—	1.29	—	—
33	13.97	1.25	1.34	1.19	—	—	—	1.16	—	—
34	13.97	1.32	1.27	1.21	—	—	—	0.80	—	—
35	13.97	1.29	1.21	1.31	—	—	—	0.76	—	—
36	13.97	1.25	1.18	1.29	—	—	—	0.74	—	—

In studying the data contained in Table XVIII, we notice the following points of interest:

(1) During the first three months, the loss of solids was very marked, though varying in degree in different experiments. The decrease of solids was more gradual after the third month.

(2) The loss was not uniform in the different experiments when the apple juice used varied in composition as in experiments 1 to 10; and even when the same apple juice was used, as in experiments 11 to 16, 17 to 21, 29 to 36, the loss of solids varied.

(3) In several cases, the amount of solids was below 2 per ct. when the acetic acid was above 4.5 per ct., as in experiments 1, 7, 8, 16, 18, 19, 20, 23, 31, 32, 33, 34.

(4) In old vinegar standing in a cask with the bung-hole open, there is evaporation of water and this may be considerable,

when the temperature is 70° or 80° F., and this results in a proportionate increase of solids. This is readily shown by the following tabulated results:

TABLE XIX.—INCREASE IN PERCENTAGE OF SOLIDS BY EVAPORATION ON STANDING.

NUMBER OF EXPERIMENT.	21 months.	33 months.	36 months.	44 months.	72 months.	80 months.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
6	2.87	3.19	3.28	3.30	——	5.86
9	2.86	3.54	3.79	3.95	——	——
11	1.56	1.47	——	——	2.33	——
15	1.47	1.72	——	——	7.45	——

(5) In contrast with increase of solids in old vinegar on standing, we have instances where the reverse process has taken place and the loss has been very marked. In these cases the loss of solids was accompanied by a loss of acetic acid as the result of some form of destructive fermentation, so that the liquids really ceased to be vinegar. In the following table we give several instances of this kind:

TABLE XX.—DECREASE OF SOLIDS BY DESTRUCTIVE FERMENTATION ON STANDING.

NUMBER OF EXPERIMENT.	Fresh.	21 months.	60 months.
	Per ct.	Per ct.	Per ct.
17	15.27	2.10	0.73
18	15.27	1.45	0.60
22	15.88	——	0.60
31	13.97	——	1.12
34	13.97	——	0.80
35	13.97	——	0.77
36	13.97	——	0.74

(6) A detailed study of the individual experiments, as given in the appendix, shows that there is quite generally a decrease of solids to a point below 2 per ct., but that sooner or later there is, under normal conditions, a subsequent increase of solids.

CIDER VINEGAR IN RELATION TO LEGAL STANDARDS.

Where a specific legal standard has been established by different states, the percentage of acetic acid and of solids is generally used as the basis of fixing such a standard. In different states, the required minimum percentage of acetic acid varies from 4 to 4.5 and that of solids from 1.25 to 2. In New York the standard is placed at 4.5 per ct. of acetic acid and 2 per ct. of cider vinegar solids. It is a matter of interest to notice how the results of our experiments harmonize with the established legal standard.

PERCENTAGE OF ACETIC ACID IN NORMAL CIDER VINEGAR.

In the 18 experiments made in casks, approximating to some extent the conditions normally prevailing in home-made cider vinegar, the acetic acid equalled or exceeded 4.5 per ct. within 24 months in 11 cases; in 2 cases it required 33 and 36 months to exceed 4.5 per ct., while in the other cases the amount required by legal standard was not reached until after 36 months.

In the 18 experiments carried on in bottles, 4.5 per ct. of acetic acid or more was formed in 3 to 18 months in 11 cases and in 3 other cases later; while in 4 cases, experiments 17, 22, 34, 36, the acetic acid did not reach 4.5 per ct. at any time. In experiments 17, 22, 24, 31, 33, 34, 35, 36, the acetic acid suffered loss by destructive fermentation.

In all the materials used in our work, there was an abundance of sugar present to form an amount of acetic acid well above 4.5 per ct. and this was, for the most part, converted into alcohol, as far as our work indicated. The loss appeared to occur in changing alcohol to acetic acid.

Provided proper material is used, that is, pure, undiluted apple juice of ripe apples, and provided the processes of fermentation are properly managed, there should be no difficulty in obtaining cider vinegar containing 5 per ct. or more of acetic acid. The present legal requirement of 4.5 per ct. of acetic acid in cider vinegar is therefore entirely reasonable.

PERCENTAGE OF SOLIDS IN NORMAL CIDER VINEGAR.

The legal standard of New York requires 2 per ct. of cider vinegar solids. In our 18 experiments made in casks, the amount of solids in the vinegar nearly reached or exceeded 2 per ct. in 6 cases, when the vinegar was 2 years old; in 12 cases, the solids were below 2 per ct. but in 7 cases rose to 2 per ct. later.

In the 18 experiments carried on in bottles, the solids were above 2 per ct. in 5 cases when the vinegar was 18 to 21 months old but dropped below 2 per ct. later; while in 13 cases the solids were below 2 per ct. but later rose in 3 cases above 2 per ct. Most of the cases where the solids kept below 2 per ct. had suffered destructive fermentation and were not in reality vinegar at all.

The method employed by us in estimating solids,—drying about 5 grams 6 to 8 hours on about 20 grams of sand at 212° F., gives results that are somewhat low as compared with drying for a shorter period of time, and the question naturally arises as to what method will give correct results. At the time we began our work, there was no uniform method in general use and we employed our method because it was in common use with materials somewhat resembling apple juice and vinegar.

Most of the laws in different States, including New York, use the expression, "solids on full evaporation over boiling water." The question at once suggests itself as to what constitutes "full evaporation." Different methods are employed by different chemists in determining solids in vinegar. Thus, in Bulletin No. 65 of the Bureau of Chemistry, U. S. Department of Agriculture, the provisional method recommended is as follows:

"Evaporate 10 cc. in a tared platinum dish of 50 mm. diameter on the steam bath to a sirupy consistency, dry for 2½ hours in the drying oven at the temperature of boiling water." Leach and Lythgoe, of the Department of Food and Drug Inspection of the Massachusetts State Board of Health, use the following method: "Five grams of vinegar are weighed into a tared, flat-bottomed platinum dish, subjected for an hour to direct contact with the live steam of a boiling water bath." That these different methods give varying results can readily be seen from the following table; in this work flat-bottomed platinum dishes of 50 mm. diameter were used:

Table XXI.—Results of Determination of Vinegar Solids by Different Methods.

Drying 1 hr. over boiling water.	Drying to syrup and then drying 2½ hrs. in oven at 212° F.	Drying on sand 8 hrs in steam oven.
Per ct.	*Per ct.*	*Per ct.*
1.58	1.41	1.35
1.65	1.58	1.55
1.73	1.54	1.43
1.76	1.73	1.70
1.77	1.61	1.58
1.84	1.79	1.75

TABLE XXI.—*Continued.*

Drying 1 hr. over boiling water.	Drying to syrup and then drying $2\frac{1}{2}$ hrs. in oven at 212° F.	Drying on sand 8 hrs. in steam oven.
Per ct.	*Per ct.*	*Per ct.*
1.87	1.81	1.70
1.88	1.78	1.70
1.91	1.86	1.78
1.92	1.88	1.79
1.95	1.88	1.77
2.00	1.91	1.81
2.04	2.01	1.78
2.10	1.91	1.79
2.12	2.26	2.20
2.13	2.22	2.17
2.21	2.20	2.15
2.26	——	1.98
2.28	——	1.97
2.32	——	2.08
2.43	——	2.25
2.64	——	2.33
2.89	2.93	2.65
2.93	2.95	2.87
3.06	2.88	2.80
3.10	3.15	3.10
3.64	3.77	3.70
6.50	——	5.86
8.59	8.78	7.44

In studying these data, we notice the following points:

(1) In general, the highest results were obtained by drying one hour on a water bath, and the lowest, by drying on sand eight hours in a steam oven.

(2) Vinegars containing 2 per ct. of solids as determined by the first method contained about 1.80 per ct. when determined by the longer drying on sand.

(3) Vinegars containing 2 per ct. of solids by the method of drying eight hours contained about 2.25 per ct. when dried one hour.

Since different methods give such varying results that a vinegar would be pronounced up to the standard by one method and below standard by another method, it would seem desirable that the somewhat vague phrase, "solids on full evaporation over boiling water," should be dropped and in its place should be substituted a specific statement of the conditions of evaporation.

From some of our results (experiments 1, 7, 8, 16, 18, 19, 20, 21, 23, 31, 32, 33, 35), it would seem that a pure cider vinegar may contain 4.5 per ct. of acetic acid or more and at the same time contain less than 2 per ct. of solids, by whatever recognized method the amount of solids is determined.

CONDITIONS COMMONLY PRODUCING CIDER VINEGAR BELOW STANDARD.

Several different conditions may cause the production of cider vinegar low in acetic acid, among the more common of which are the following:

1. Poor apple juice.
2. Conditions unfavorable to the necessary fermentation processes.
3. Lack of proper care after acid is formed.

POOR APPLE JUICE AS A SOURCE OF POOR VINEGAR.

By poor apple juice we mean apple juice containing less than a normal amount of sugar, that is, less sugar than would be sufficient under normal conditions of fermentation to produce vinegar containing 4.5 per ct. of acetic acid. We should be able ordinarily to produce about 50 to 55 parts by weight of acetic acid for each 100 parts of sugar present in the fresh juice. Hence, to produce cider vinegar with the amount of acetic acid required by the legal standard, we should need to use apple juice containing 8.25 to 9 per ct. of sugar.

There are five different conditions under which apple juice may contain less than the amount of sugar indicated: (1) The fruit may be unripe; (2) the apple juice, normal at the start, may be watered; (3) the juice may be made by treating the pomace with water, allowing to stand and pressing a second time;. (4) the apples may be badly decayed; (5) apples may be used which normally contain, even when ripe, an insufficient amount of sugar. Among such, according to the results given in Table II, are the following: Ben Davis, Gano, Loy and Montreal Beauty Crab. We do not mean to say that these varieties never contain enough sugar for cider-making, but simply that the samples analyzed did not.

CONDITIONS UNFAVORABLE TO THE NECESSARY FERMENTATION PROCESSES.

We will mention the following conditions as most common among those that unfavorably affect the processes of fermantation: (1) Dirty and decayed fruit, (2) unclean barrels, (3) too low temperature, (4) lack of air, due either to filling the barrel too full or stopping the bung-hole.

(1) *Dirty fruit.*—It is quite common that the apples used for vinegar-making are refuse left lying on the ground until they become covered with soil and more or less decayed. Under such conditions, there is serious danger of getting into the apple juice organisms that will interfere with the regular alcoholic and acetic fermentations, particularly the latter, either by lessening the amount of those products or by producing undesirable flavors.

(2) *Unclean barrels.*—Barrels or casks are frequently used for vinegar-making, which are not previously cleaned, no matter what their previous condition or use. Undesirable organisms may be brought into contact with the apple juice in this way.

(3) *Storing apple juice at too low temperature.*—Many, if not most, farmers place their barrels of apple juice at once in the cool temperature of a cellar, where it will usually require 6 months or more to complete the alcoholic fermentation. The material is left at the same temperature for the acetic fermentation which takes place with extreme slowness. In some cases, it may require three years or more before the acetic fermentaiton is completed under these conditions, and ordinarily the time is two years or more.

(4) *Lack of air.*—The acetic fermentation requires the presence of air, and this may be excluded by filling the barrel too full or by putting the bung in tight or by doing both at once. It often happens that the conditions have all been favorable and that the vinegar is apparently sour enough; the bung is then tightly stoppered, when an analysis would show less than 4 per ct. of acid. Before closing the barrel it would be well to have the amount of acid determined as soon as the vinegar seems sufficiently sour. When the barrel is thus tightly stoppered before the formation of acid is completed, the fermentation soon ceases and the amount of acid does not increase further.

LACK OF PROPER CARE AFTER ACID IS FORMED.

When the alcoholic fermentation is completed and the cider has become commercial cider vinegar of good quality, destructive fermentation of the acid may be encouraged by leaving the bung-hole open and the barrel only partially full.

DIRECTIONS FOR HOME-MANUFACTURE OF CIDER VINEGAR.

KIND OF APPLES TO USE.

Only ripe apples should be used, possessing a sugar content of not less than 8.5 per cent. Most varieties of apples commonly available possess the requisite amount of sugar when ripe, but not when green. The apples should not be decayed or over-ripe, because the amount of sugar is lessened in such apples. The apples should be clean when gathered and if not, they should be made so by washing. The objection to dirt in the apple juice is the danger of introducing forms of fermentation that will interfere with the normal alcoholic and acetic fermentations which are desired. One objection raised to washing apples is the liability to remove the germs that cause the desired forms of fermentation. While in our own practice we have not met with such difficulty, it is preferable that the apples shall, if possible, be clean when gathered.

PREPARATION OF APPLE JUICE.

In the grinding and pressing of the apples care should be taken to observe ordinary precautions of cleanliness. In many cases, it is the practice to add water to the apple pomace after pressing, let it stand awhile and press again. This treatment yields an additional amount of juice, which, however, does not contain the requisite amount of sugar to make good vinegar, providing the first pressing has been efficient. Avoid the use of juice made from second pressing.

PUTTING APPLE JUICE IN BARRELS.

When practicable, it is a good plan to store the freshly pressed apple juice in some large receptacle and allow it to stand a few days, before putting it into barrels. In this way considerable solid matter held in suspension will settle before the liquid is placed in casks. The casks used should be well cleaned, thoroughly treated with live steam or boiling water, and should not be over two-thirds or three-fourths filled with apple juice.

The bung should be left out, but a loose plug of cotton may be placed in the hole to decrease evaporation and prevent dirt falling in. The bung should be left out until 4.5 to 5.0 per ct. of acetic acid has formed.

MANAGEMENT OF ALCOHOL FERMENTATION.

When the freshly pressed apple juice is at once placed in ordinary cellars, where the temperature during winter does not go below 45° or 50° F., the alcoholic fermentation is complete in about six months, assuming that the work is begun in October or November; though 80 to 90 per ct. of the alcohol is formed in half this time or less. By having the fermentation take place at a temperature of 65° or 70° F., the time can be considerably reduced; however it is not desirable to have the alcoholic fermentation take place much above 70° F., since the loss of alcohol by evaporation is increased. By the addition of yeast to the fresh apple juice, the fermentation can be completed in three months or less, especially if the temperature is near 65° or 70° F. It is suggested that one Fleischmann's compressed yeast cake, or an equivalent, may be used for five gallons of apple juice, if one desires to use yeast. The yeast cake is stirred with a cup of water and after complete disintegration is mixed with the juice. Whatever form of yeast is used, it should be fresh. Vinegar or "mother" should never be added to apple juice.

MANAGEMENT OF ACETIC FERMENTATION.

When the alcoholic fermentation is completed, it is well to draw off the clear portion of liquid, rinse out the cask, replace the clear liquid, add two or four quarts of good vinegar containing more or less "mother" and place at a temperature of 65° to 75° F. The acetic fermentation occupies from 3 to 18 months or more, according to the conditions under which the fermentation is carried on. When the apple juice is stored in cool cellars and left there until it becomes vinegar of legal standard, it requires from 21 to 24 months or even more. When the alcoholic fermentation is allowed to take place in a cool cellar and the casks then removed to a warmer place, the time of vinegar formation may be reduced from that given above to 15 to 18 months. Where the alcoholic fermentation is hastened by the use of yeast and the acetic fermentation favored by the proper temperature and addition of a vinegar "starter," it is possible to produce good merchantable vinegar in casks in 6 to 12 months. In vinegar factories the formation of acetic acid is greatly hastened by the use of "generators," in which the alcoholic liquid is brought into intimate contact with a large supply of air. In the hands of the ordinary farmer, making only a few barrels of cider, these generators would probably not be found entirely practicable in every way.

CARE OF CIDER VINEGAR.

When the acetic fermentation has gone far enough to produce 4.5 to 5 per ct. of acetic acid, then the barrels should be made as full as possible and tightly corked, in order to prevent destructive fermentation of acetic acid and consequent deterioration of the vinegar.

APPENDIX.

In the following pages, we give the full details of the analytical results and also the special conditions of experiment in each of the 36 experiments described in the bulletin.

EXPERIMENT 1.—JUICE PRESSED FROM NORTHERN SPY APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR; STRAINED AT END OF SIX MONTHS AND REPLACED IN CLEANED CASK.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0640	15.24	0.19	0.015	10.08	2.69	0.00	0.02	0.52
1	1.0640	15.10	0.19	0.015	10.08	2.48	0.04	0.04	0.50
2	1.0363	10.05	0.19	0.009	7.83	0.28	2.84	0.06	0.48
3	1.0200	7.12	0.22	0.005	4.95	0.12	4.23	0.20	0.46
4	1.0079	4.85	0.24	0.004	2.77	0.01	5.52	0.16	0.46
5	0.9985	2.39	0.24	0.003	0.78	0.00	6.74	0.16	0.45
6	0.9980	2.30	0.25	0.002	0.22	———	6.84	0.10	0.46
7	0.9978	2.25	0.25	0.002	0.13	———	6.79	0.17	0.42
8	0.9982	2.12	0.24	0.002	———	———	6.31	0.38	0.44
9	0.9988	2.15	0.24	———	———	———	5.74	0.84	0.24
10	0.9992	1.98	0.24	———	———	———	5.23	1.01	0.02
14	1.0005	1.61	0.23	———	———	———	4.10	2.33	0.03
15	1.0032	1.53	0.24	———	———	———	3.69	2.18	0.02
21	1.0081	———	———	———	———	———	2.92	3.93	0.02
24	1.0149	1.58	0.26	0.001	———	———	1.05	6.14	0.02
27	1.0158	1.56	0.29	———	———	———	0.91	6.39	0.02
29	1.0158	1.66	0.26	———	———	———	———	6.47	0.02
33	1.0196	1.63	———	———	———	———	0.00	7.76	0.02
36	1.0202	1.58	———	———	———	———	———	7.77	0.01
44	———	1.60	———	———	———	———	———	7.97	———

EXPERIMENT 2.—JUICE PRESSED FROM NORTHERN SPY APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR FOR FIVE MONTHS AND THEN PLACED IN A ROOM OF HIGHER TEMPERATURE; TRANSFERRED FROM CASK TO STOPPERED BOTTLE AFTER 33D MONTH.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0650	15.48	0.19	0.014	9.95	3.43	0.00	0.03	0.51
1	1.0645	15.36	0.16	0.013	9.81	3.16	0.06	0.04	0.48
2	1.0306	8.98	0.22	0.005	6.64	0.73	3.45	0.08	0.47
3	1.0160	6.19	0.24	0.003	4.00	0.31	4.91	0.21	0.44
4	1.0071	4.81	0.26	0.003	2.67	0.06	5.74	0.22	0.38
5	0.9990	2.73	0.24	0.003	0.82	0.04	6.89	0.25	0.40
6	0.9982	2.60	0.24	0.003	0.27	0.02	7.05	0.25	0.39
7	0.9974	2.47	0.24	0.002	0.17	0.01	6.97	0.26	0.39
8	0.9962	2.34	0.25	0.002	———	0.00	6.79	0.27	0.09
9	0.9961	2.29	0.27	———	———	———	6.78	0.29	0.09
10	0.9967	2.15	0.24	———	———	———	6.17	0.58	0.04
14	1.0084	2.09	0.26	———	———	———	3.20	4.44	0.01
15	1.0087	1.74	0.26	———	———	———	3.21	4.60	0.01
16	1.0090	1.72	———	———	———	———	3.07	4.63	0.01
21	1.0223	———	———	———	———	———	0.00	9.22	0.02
24	1.0228	1.75	———	0.003	———	———	———	9.56	0.02
33	1.0258	1.86	———	———	———	———	———	9.81	0.01
36	1.0233	1.72	———	———	———	———	———	9.76	0.02
44	———	1.76	———	———	———	———	———	9.70	———

EXPERIMENT 3.—JUICE PRESSED FROM NORTHERN SPY APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR FOR FIVE MONTHS AND THEN PLACED IN A ROOM OF HIGHER TEMPERATURE; STRAINED AT THE END OF SIX MONTHS AND REPLACED IN CLEANED CASK.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0640	15.12	0.20	0.013	9.73	3.12	0.00	0.04	0.49
1	1.0620	14.74	0.19	0.012	9.55	3.06	0.15	0.06	0.48
2	1.0247	7.77	0.24	0.006	5.80	0.49	3.88	0.15	0.47
3	1.0130	5.60	0.24	0.002	3.64	0.09	4.95	0.25	0.40
4	1.0630	4.07	0.26	0.003	2.50	———	5.71	0.21	0.37
5	0.9990	2.51	0.23	0.002	0.88	———	6.74	0.25	0.37
6	0.9976	2.43	0.25	0.002	0.27	———	6.77	0.19	0.63
7	0.9973	2.37	0.25	0.002	0.17	0.92	6.76	0.34	0.34
8	0.9973	2.29	0.24	0.002	———	———	6.51	0.34	0.11
9	0.9969	2.27	0.26	———	———	———	6.27	0.49	0.08
10	0.9981	2.21	———	———	———	———	5.65	0.92	0.03
11	1.0075	2.02	0.23	———	———	———	3.40	4.00	0.01
12	1.0077	1.94	0.25	———	———	———	3.31	4.08	0.01
16	1.0083	1.83	———	———	———	———	3.21	4.19	0.01
21	1.0168	2.01	———	———	———	———	1.30	7.01	0.02
24	1.0225	1.82	0.32	0.002	———	———	———	9.06	0.02
27	1.0214	1.89	0.30	———	———	———	———	8.80	0.02
29	1.0216	1.85	0.30	———	———	———	———	8.71	0.02
33	1.0249	2.01	———	———	———	———	———	9.99	0.01
36	1.0265	2.06	———	———	———	———	———	10.23	0.02
44	———	2.81	———	———	———	———	———	11.05	———

EXPERIMENT 4.—JUICE PRESSED FROM ROXBURY RUSSET APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mth.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0690	16.46	0 23	0.021	8.85	5.28	0.00	0.04	0.63
1	1.0670	16.00	0.20	0.016	8.64	4.19	0.38	0.08	0.63
2	0.0195	6.97	0.19	0.008	4.16	0.86	5.13	0.14	0.59
3	1.0095	5.19	0.23	0.004	2.52	0.23	6.04	0.17	0.50
4	1.0040	3.89	0.24	0.003	1.60	0.12	6.88	0.21	0.44
5	1.0000	3.32	0.24	0.002	0.95	———	7.20	0.28	0.42
6	1.0000	3.21	0.25	0.003	0.32	0.03	7.31	0.24	0.41
7	0.9997	3.14	0.25	———	0.22	0.03	7.32	0.27	0.41
8	0.9989	3.01	0.25	———	———	———	7.21	0.27	0.18
9	0.9985	2.95	0.26	———	———	———	6.79	0.25	0.09
10	0.9982	2.89	0.24	———	———	———	6.47	0.31	0.05
14	0.9988	2.65	0.24	———	———	———	6.47	0.35	0.07
15	0.9990	2.53	0.25	———	———	———	6.44	0.32	0.10
21	0.9997	2.29	———	———	———	———	5.91	0.36	0.07
24	1.0014	2.05	0.27	0.002	———	———	5.33	0.73	0.07
27	1.0034	2.03	0.28	———	———	———	4.58	1.43	0.05
29	1.0035	2.12	0.28	———	———	———	———	1.46	0.06
33	1.0125	2.12	———	———	———	———	1.79	4.23	0.01
36	1.0205	1.91	———	———	———	———	———	6.58	0.01
44	———	1.96	———	———	———	———	———	6.82	0.01

EXPERIMENT 5.—JUICE PRESSED FROM ROXBURY RUSSET APPLES NOVEMBER 10, 1897; STORED IN CELLAR IN 10-GALLON CASK; ONE PINT OF VINEGAR ADDED AT END OF EIGHT MONTHS.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0720	16.85	0.20	0.020	9.06	5.46	0.00	0.02	0.66
1	1.0710	16.79	0.18	0.017	8.79	4.74	0.05	0.04	0.65
2	1.0493	12.82	0.19	0.014	7.73	2.22	2.58	0.18	0.61
3	1.0255	8.42	0.25	0.008	5.10	0.60	4.53	0.19	0.56
4	1.0115	5.71	0.26	0.007	2.60	0.26	6.13	0.22	0.47
5	1.0000	3.37	0.25	0.004	0.85	0.05	7.36	0.22	0.49
6	1.0009	3.25	0.25	0.003	0.30	0.05	7.56	0.21	0.48
7	0.9999	3.17	0.26	0.004	0.22	0.04	7.48	0.20	0.49
8	0.9993	3.11	0.26	0.004	———	———	7.50	0.31	0.10
9	0.9983	2.95	0.26	———	———	———	7.96	0.31	0.10
10	0.9984	2.89	0.25	———	———	———	6.83	0.30	0.08
14	0.9986	2.55	0.25	———	———	———	6.69	0.29	0.07
15	0.9988	2.43	0.27	———	———	———	6.60	0.31	0.10
21	1.0004	2.42	———	———	———	———	5.78	0.61	0.08
24	1.0135	1.96	0.27	0.003	———	———	1.95	5.15	0.01
27	1.0179	1.93	0.28	———	———	———	0.95	6.65	0.01
29	1.0186	2.03	0.28	———	———	———	———	6.83	0.02
33	1.0213	2.02	———	———	———	———	0.00	7.52	0.01
36	1.0210	2.00	———	———	———	———	———	7.05	0.02
44	———	2.01	———	———	———	———	———	6.76	0.02

EXPERIMENT 6.—JUICE PRESSED FROM MIXED WINTER APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR FOR FIVE MONTHS AND THEN PLACED IN A ROOM OF HIGHER TEMPERATURE.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0740	17.19	0.28	0.023	9.23	5.78	0.00	0.05	0.62
1	1.0720	17.14	0.20	0.019	8.79	4.69	0.07	0.03	0.62
2	1.0616	15.03	0.20	0.016	8.72	3.34	1.33	0.08	0.60
3	1.0255	9.11	0.25	0.011	5.18	0.70	4.49	0.18	0.53
4	1.0119	5.45	0.27	0.010	2.53	0.34	6.13	0.17	0.56
5	1.0010	3.64	0.25	0.004	0.63	0.11	7.56	0.20	0.50
6	1.0006	3.55	0.26	0.003	0.33	0.07	7.53	0.21	0.47
7	1.0005	3.46	0.26	0.004	0.26	0.04	7.40	0.21	0.46
8	0.9989	3.31	0.26	0.004	———	———	7.42	0.30	0.07
9	0.9991	3.15	0.27	———	———	———	7.37	0.32	0.09
10	0.9992	3.03	0.26	———	———	———	7.26	0.31	0.10
14	1.0067	2.71	0.26	———	———	———	4.93	2.90	0.03
15	1.0070	2.80	0.27	———	———	———	4.95	2.88	0.02
16	1.0070	2.83	———	———	———	———	4.99	2.89	0.03
21	1.0157	2.87	———	———	———	———	2.82	5.59	0.04
24	1.0262	2.92	0.32	———	———	———	0.34	9.19	0.03
27	1.0263	2.81	0.35	———	———	———	0.00	9.02	0.04
29	1.0250	2.83	0.34	———	———	———	———	8.90	0.03
33	1.0286	3.19	———	———	———	———	———	9.97	0.03
36	1.0390	3.28	———	———	———	———	———	10.23	0.02
44	———	3.30	———	———	———	———	———	10.81	0.02
80	1.0431	5.86	0.67	———	———	———	———	16.98	0.04

EXPERIMENT 7.—JUICE PRESSED FROM BALDWIN APPLES NOVEMBER 10, 1897; STORED IN 10-GALLON CASK IN CELLAR; CLEAR PORTION SIPHONED OFF AND REPLACED IN CLEANED CASK AT END OF SIX MONTHS.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	14.43	0.23	0.017	8.57	4.37	0.00	0.04	0.59
1	1.0590	14.14	0.18	0.013	8.33	2.96	0.09	0.10	0.53
2	1.0529	13.07	0.20	0.014	7.85	2.41	0.63	0.17	0.48
3	1.0215	7.05	0.25	0.010	4.42	0.40	3.75	0.15	0.45
4	1.0028	3.39	0.25	0.007	1.46	0.12	5.64	0.17	0.43
5	1.0000	2.60	0.25	0.005	0.49	0.10	6.19	0.17	0.44
6	0.9992	2.45	0.24	0.005	0.28	0.05	6.29	0.20	0.37
7	0.9990	2.51	0.25	0.004	0.21	0.04	6.67	0.26	0.27
8	0.9980	2.37	0.26	0.003	———	———	5.77	0.30	0.06
9	0.9981	2.29	0.27	———	———	———	5.59	0.33	0.06
10	0.9990	2.20	0.27	———	———	———	5.08	0.53	0.05
14	1.0020	1.90	0.25	———	———	———	4.09	1.01	0.02
15	1.0020	1.81	0.26	———	———	———	3.89	1.01	0.03
21	1.0109	1.94	———	———	———	———	1.51	3.75	0.01
24	1.0169	1.79	0.28	0.002	———	———	0.08	5.69	0.01
27	1.0176	1.70	0.30	———	———	———	0.00	6.04	0.01
29	1.0179	1.69	0.29	———	———	———	———	6.13	0.02
33	1.0177	1.74	———	———	———	———	———	5.95	0.02
36	1.0185	1.69	———	———	———	———	———	5.79	0.02
44	———	1.88	———	———	———	———	———	6.13	0.02

EXPERIMENT 8.—JUICE PRESSED FROM REINETTE PIPPIN APPLES NOVEMBER 11, 1897; STORED IN 10-GALLON CASK IN CELLAR; CLEAR PORTION SIPHONED OFF AND REPLACED IN CLEANED CASK AT SIX MONTHS AND ONE PINT OF VINEGAR ADDED AT END OF EIGHT MONTHS.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0560	13.50	0.21	0.010	9.14	2.67	0.00	0.04	0.47
1	1.0555	13.41	0.17	0.007	9.08	2.21	0.08	0.07	0.47
2	1.0438	11.18	0.19	0.006	8.75	0.02	1.20	0.10	0.45
3	1.0245	7.37	0.22	0.003	5.45	0.16	3.07	0.16	0.44
4	1.0140	5.13	0.26	0.003	3.43	0.12	4.14	0.16	0.44
5	1.0010	2.63	0.24	0.003	0.82	0.07	5.68	0.14	0.47
6	0.9986	2.54	0.25	0.002	0.29	0.03	5.81	0.20	0.41
7	0.9985	2.43	0.25	0.001	0.19	0.03	5.88	0.25	0.29
8	0.9979	2.47	0.25	0.001	———	———	5.49	0.47	0.08
9	0.9994	2.32	0.25	———	———	———	4.82	0.93	0.07
10	1.0006	2.19	0.25	———	———	———	4.30	1.18	0.06
14	1.0055	1.81	0.25	———	———	———	2.98	2.78	0.02
15	1.0054	1.70	0.25	———	———	———	2.72	2.66	0.02
21	1.0127	1.65	———	———	———	———	1.17	5.03	0.01
24	1.0173	1.50	0.28	0.001	———	———	0.00	6.65	0.02
27	1.0179	1.45	0.29	———	———	———	———	6.80	0.02
29	1.0180	1.50	0.29	———	———	———	———	6.81	0.02
33	1.0184	1.49	———	———	———	———	———	6.88	0.02
36	1.0191	1.50	———	———	———	———	———	6.98	0.02
44	———	1.55	———	———	———	———	———	7.30	0.01

EXPERIMENT 9.—JUICE PRESSED FROM MIXED FALL AND WINTER APPLES NOVEMBER 11, 1897; STORED IN 10-GALLON CASK IN CELLAR FOR FIVE MONTHS AND THEN PLACED IN A ROOM OF HIGHER TEMPERATURE; AT THE END OF SIX MONTHS CLEAR PORTION SIPHONED OFF AND REPLACED IN CLEAN CASK; ONE PINT OF VINEGAR ADDED AT END OF EIGHT MONTHS.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0650	15.43	0.27	0.016	9.[illegible]3	4.26	0.00	0.03	0.51
1	1.0630	15.18	0.20	0.014	8.96	3.53	0.16	0.05	0.50
2	1.0303	8.96	0.20	0.010	6.72	0.13	3.69	0.18	0.50
3	1.0045	3.89	0.25	0.005	1.81	0.10	6.04	0.17	0.48
4	0.9990	2.83	0.26	0.003	0.91	0.09	6.17	0.18	0.43
5	0.9995	2.62	0.25	0.002	0.49	0.06	6.82	0.18	0.44
6	0.9986	2.69	0.26	0.002	0.27	0.05	6.83	0.20	0.40
7	0.9984	2.76	0.26	0.003	0.20	0.04	6.65	0.23	0.32
8	0.9978	2.71	0.26	0.001	———	———	6.27	0.47	0.11
9	0.9963	2.73	0.27	———	———	———	5.82	0.98	0.09
10	1.0015	2.65	0.27	———	———	———	5.29	1.61	0.06
14	1.0089	2.61	0.28	———	———	———	3.44	3.96	0.05
15	1.0095	2.37	0.29	———	———	———	3.44	4.04	0.05
16	1.0099	2.49	———	———	———	———	3.37	4.16	0.06
21	1.0202	2.86	———	———	———	———	1.39	7.33	0.04
24	1.0269	2.79	0.39	0.002	———	———	0.03	9.49	0.05
27	1.0266	2.71	0.42	———	———	———		9.41	0.06
29	1.0286	2.94	0.44	———	———	———		10.03	0.06
33	1.0341	3.54	———	———	———	———		11.66	0.08
36	1.0404	3.79	———	———	———	———		13.23	0.02
44	———	3.95	———	———	———	———		12.96	0.02

EXPERIMENT 10.—JUICE PRESSED FROM MIXED FALL AND WINTER APPLES NOVEMBER 11, 1897; STORED IN 10-GALLON CASK IN CELLAR FOR FIVE MONTHS AND THEN PLACED IN A ROOM OF HIGHER TEMPERATURE.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mth.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0570	13.73	0.18	0.014	9.23	3.01	0.00	0.03	0.41
1	1.0555	13.38	0.18	0.007	8.97	2.15	0.06	0.07	0.39
2	1.0278	8.05	0.22	0.006	6.52	0.03	2.95	0.12	0.40
3	1.0075	4.26	0.23	0.003	2.63	0.04	4.81	0.15	0.38
4	0.9997	2.73	0.25	0.002	1.21	0.03	5.81	0.17	0.38
5	0.9995	2.19	0.24	0.002	0.51	0.04	6.07	0.17	0.38
6	0.9982	2.15	0.23	0.002	0.30	0.01	6.10	0.20	0.35
7	0.9975	2.17	0.24	0.001	0.22	0.01	5.94	0.34	0.13
8	0.9978	2.11	0.24	0.001	0.00	———	5.62	0.58	0.06
9	0.9986	2.06	0.25	———	———	———	5.25	0.65	0.07
10	1.0007	1.93	0.25	———	———	———	4.60	1.35	0.09
14	1.0078	1.95	0.25	———	———	———	2.93	3.66	0.03
15	1.0077	1.86	0.26	———	———	———	2.64	3.56	0.03
16	1.0084	1.80	———	———	———	———	2.78	3.82	0.04
21	1.0181	2.20	———	———	———	———	0.72	7.06	0.03
24	1.0224	1.92	0.36	0.002	———	———	0.00	8.50	0.03
27	1.0196	1.95	0.33	———	———	———	———	8.55	0.02
29	1.0225	1.97	0.37	———	———	———	———	8.78	0.02
33	1.0263	2.32	———	———	———	———	———	9.93	0.02
36	1.0290	2.46	———	———	———	———	———	10.64	0.02
44	———	2.17	———	———	———	———	———	10.51	0.02

EXPERIMENT 11.—JUICE PRESSED FROM MIXED FALL AND WINTER APPLES OCTOBER 19, 1898; STORED IN 20-GALLON CASKS IN CELLAR; ONE QUART OF VINEGAR ADDED AT END OF TWO MONTHS.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	14 01	0.27	0.020	7.49	4.33	0.00	0.03	0.59
2	1.0260	7.25	0.29	0.016	4.64	0.53	3.74	0.11	0.54
3	1.0053	3.64	0.28	0.011	1.10	0.18	5.45	0.28	0.49
4	1.0039	2.79	0.22	0.010	0.74	———	5.60	0.32	0.39
5	1.0030	2.80	———	0.010	0.27	———	5.71	0.30	0.30
10	0.9992	2.26	———	———	———	———	5.68	0.25	0.09
12	0.9988	1.94	———	———	———	———	5.61	0.25	0.12
16	0.9992	1.75	———	———	———	———	5.41	0.27	0.10
18	1.0091	1.59	0.29	0.004	———	———	5.16	0.31	0.09
22	1.0013	1.56	———	———	———	———	3.88	0.65	0.03
26	1.0051	1.42	———	———	———	———	2.43	1.45	0.02
33	1.0101	1.47	———	———	———	———	0.68	3.12	0.02
72	1.0192	2.33	0.43	———	———	———	———	7.42	0.01

Experiment 12.—Material, Time and Treatment Same as in 11, Except that no Vinegar was Added.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	14.01	0.27	0.020	7.49	4.33	0.00	0.03	0.59
2	1.0250	7.54	0.27	0.016	4.85	0.67	3.71	0.16	0.51
3	1.0013	2.86	0.26	0.009	0.50	0.09	5.11	0.17	0.50
4	1.0006	2.65	0.23	0.009	0.28	0.02	5.34	0.22	0.46
5	1.0005	2.35	——	0.009	0.12	——	5.60	0.20	0.41
10	1.0006	2.24	——	——	——	——	5.67	0.22	0.38
12	0.9980	1.82	——	——	——	——	5.81	0.23	0.15
16	0.9983	1.65	——	——	——	——	5.51	0.30	0.11
18	0.9987	1.59	0.29	0.004	——	——	5.44	0.37	0.10
22	1.0011	1.51	——	——	——	——	3.93	0.56	0.03
26	1.0050	1.24	0.29	——	——	——	2.22	1.57	0.01
33	1.0109	1.23	——	——	——	——	0.36	3.52	0.01
72	1.0176	1.97	0.46	——	——	——	——	6.78	0.00

Experiment 13.—Material, Time and Treatment Same as in 12.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by wieght.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*
Fresh	1.0600	14.01	0.27	0.020	7.49	4.33	0.00	0.03	0.59
2	1.0300	8.16	0.27	0.015	5.45	0.72	3.10	0.18	0.49
3	1.0015	2.91	0.26	0.008	0.49	0.20	4.78	0.19	0.50
4	1.0008	2.42	0.22	0.009	0.31	0.00	5.39	0.24	0.43
5	1.0006	2.39	——	0.007	0.13	——	5.61	0.19	0.37
10	0.9998	2.37	——	——	——	——	5.86	0.30	0.18
12	0.9978	1.76	——	——	——	——	5.86	0.32	0.15
16	0.9983	1.64	——	——	——	——	5.72	0.36	0.14
18	0.9987	1.37	0.29	0.005	——	——	5.51	0.50	0.09
22	1.0005	1.40	——	——	——	——	4.20	0.63	0.03
26	1.0075	1.30	——	——	——	——	2.06	2.96	0.01
33	1.0137	1.31	——	——	——	——	0.20	5.32	0.01
72	1.0158	2.25	0.46	——	——	——	——	——	0.00

Experiment 14.—Same as in 12 and 13.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mth.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	1.40	0.27	0.010	7.49	4.03	——	——	0.50
2	1.0280	7.73	0.27	0.015	5.22	0.54	3.27	0.18	0.52
3	1.0040	3.33	0.27	0.012	0.84	0.19	5.72	0.18	0.49
4	1.0032	3.02	0.25	0.010	0.61	0.01	5.78	0.20	0.47
5	1.0020	2.81	——	0.009	0.17	——	5.94	0.24	0.43
10	1.0007	2.66	——	——	——	——	5.86	0.28	0.37
12	0.9987	1.93	——	——	——	——	5.95	0.34	0.13
16	0.9985	1.68	——	——	——	——	5.76	0.31	0.16
18	0.9987	1.51	0.28	0.003	——	——	5.42	0.35	0.08
22	0.9995	1.50	——	——	——	——	4.76	0.33	0.06
26	1.0029	1.39	——	——	——	——	3.62	1.61	0.04
33	1.0049	1.24	——	——	——	——	2.73	2.49	0.03

EXPERIMENT 15.—SAME MATERIAL AS IN PRECEDING. AFTER TWO MONTHS, ONE QUART OF VINEGAR WAS ADDED AND THE CASK WAS PLACED IN A WARM ROOM.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	14.01	0.27	0.020	7.49	4.33	0.00	0.03	0.59
2	1.0240	7.14	0.30	0.015	4.64	0.62	3.51	0.19	0.50
3	1.0010	2.92	0.27	0.004	0.41	0.22	5.68	0.34	0.48
4	1.0009	2.67	0.26	0.004	0.24	0.00	5.71	0 34	0.47
5	1.0009	2.58	———	0.003	0.10	———	5.77	0.35	0.41
10	0.9996	2.40	———	———	———	———	5.88	0.39	0.30
12	0.9990	1.94	———	———	———	———	5.60	0.54	0.09
16	0.9933	1.68	———	———	———	———	4.45	1.87	0.04
18	1.0023	1.51	0.36	0.002	———	———	3 44	4.20	0.01
22	1.0140	1.47	———	———	———	———	1.58	5.75	0.01
26	1.0157	1.42	———	———	———	———	1.54	5.91	0.01
33	1.0235	1.72	———	———	———	———	0.01	8.95	0.01
72	1.0534	7.45	1.11	———	———	———	———	21.00	0.05

EXPERIMENT 16.—SAME AS 15, EXCEPT THAT NO VINEGAR WAS ADDED.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0600	14.01	0.27	0.020	7.49	4.33	0.00	0.03	0.59
3	1.0190	6.10	0.28	0.016	3.42	0.79	4.16	0.20	0.48
2	1.0007	2.77	0.26	0.004	0.39	0.17	5.87	0.18	0.47
4	1.0004	2.55	0.27	0.004	0.24	0.00	5.89	0.18	0.47
5	1.0000	2.36	———	0 003	0.10	———	6.10	0.25	0.39
10	0.9980	2.24	———	———	———	———	6.03	0.25	0.16
12	0.9942	1.79	———	———	———	———	5.29	1.02	0.06
16	1.0000	1.75	———	———	———	———	4.65	1.96	0.02
18	1.0023	1.48	0.30	0.002	———	———	3.88	3.09	0.01
22	1.0119	1 64	———	———	———	———	2 47	5.12	0.01
26	1.0155	1.64	———	———	———	———	2.10	5.90	0.01
33	1.0193	2.14	———	———	———	———	1.93	7.31	0.01

EXPERIMENT 17.—JUICE PRESSED FROM MIXED FALL AND WINTER APPLES OCTOBER 24, 1899; STORED IN QUART BOTTLES AT 55° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.27	0.31	0.021	10.34	2.68	0.00	0 00	0.41
3	1.0182	3.80	0.28	0.007	2.40	0.08	2 24	2.57	0.20
6	1.0179	3.26	———	———	1.77	———	1.09	3.47	0.16
9	1.0197	2.84	0.32	0.002	1.72	———	———	4.29	0.16
14	1.0167	2.30	———	———	1.69	———	———	2.90	0.13
15	1.0217	2.31	———	———	1.66	———	———	2.60	0.13
21	1.0022	2.10	———	———	1.27	———	———	1.43	———
60(*a*)	1.0038	0.52	0.28		———			alkaline	0.00
60(*b*)	1.0035	0.84	0.27		———			0.00	0.00
60(c)	1.0033	0.84	0.27		———			0.00	0.00

EXPERIMENT 18.—SAME AS 17, EXCEPT THAT THE TEMPERATURE WAS KEPT AT 60° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.27	0.31	0.021	10.34	2.68	0.00	0.00	0.41
3	1.0016	1.77	0.26	0.006	0.32	0.05	4.82	1.41	0.05
6	1.0109	1.61	———	———	0.24	———	1.73	4.30	0.02
9	1.0125	1.58	0.29	0.003	———	———	1.23	4.79	0.02
14	1.0157	1.37	———	———	———	———	0.08	5.40	0.01
15	1.0160	1.41	———	———	———	———	0.04	5.31	0.01
21	1.0139	1.45	———	———	———	———	———	4.87	0.01
60 (a)	1.0139	1.70	0.27		———	———	———	5.74	0.03
60 (b)	1.0122	1.58	0.28		———	———	———	5.44	0.00
60 (c)	1.0095	1.70	0.27		———	———	———	2.10	0.00
60 (d)	1.0029	0.60	0.29		———	———	———	alkaline	0.00

EXPERIMENT 19.—SAME AS 17, EXCEPT THAT THE TEMPERATURE WAS KEPT AT 65° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.27	0.31	0.021	10.34	2.68	0.00	0.00	0.41
3	1.0030	1.63	0.25	0.007	0.41	0.03	4.53	2.25	0.04
6	1.0174	1.51	———	———	0.27	———	0.35	7.02	0.01
9	1.0187	1.49	0.28	0.003	———	———	———	7.66	0.01
14	1.0188	1.32	———	———	———	———	0.00	6.87	0.01
15	1.0186	1.33	———	———	———	———	———	7.01	0.01
21	1.0176	1.45	———	———	———	———	———	6.94	0.01
60 (a)	1.0109	1.55	0.25		———	———	———	4.00	0.00
60 (b)	1.0190	1.78	0.25		———	———	———	10.00	0.00
60 (c)	1.0184	1.75	0.27		———	———	———	8.18	0.00
60 (d)	1.0186	1.79	0.24		———	———	———	8.40	0.00

EXPERIMENT 20.—SAME AS 17, EXCEPT THAT THE TEMPERATURE WAS KEPT AT 70° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.27	0.31	0.021	10.34	2.68	0.00	0.00	0.41
3	0.9978	1.66	0.25	0.009	9.25	0.03	6.41	0.70	0.08
6	1.0106	1.62	———	———	0.20	———	2.73	4.96	0.03
9	1.0162	1.54	0.27	0.006	———	———	0.74	7.04	0.01
14	1.0196	1.52	———	———	———	———	0.03	7.76	0.01
15	1.0198	1.58	———	———	———	———	0.00	7.72	0.01
21	1.0191	1.61	———	———	———	———	———	7.79	0.01
60 (a)	1.0180	1.81	0.25		———	———	———	8.50	0.00
60 (b)	1.0188	1.79	0.26		———	———	———	8.48	0.00
60 (c)	1.0188	1.77	0.25		———	———	———	8.40	0.00

EXPERIMENT 21.—SAME AS 17, EXCEPT THAT THE TEMPERATURE WAS KEPT AT 85° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.27	0.31	0.021	10.34	2.68	0.00	0.00	0.41
3	0.9972	1.65	0.26	0.009	0.14	0.04	6.66	0.18	0.10
6	0.9979	1.69	——	——	0.14	——	6.08	0.25	0.10
9	1.0068	1.78	0.28	0.009	——	——	3.42	3.40	0.05
14	1.0102	1.45	——	——	——	——	2.17	4.22	0.01
15	1.0113	1.47	——	——	——	——	1.79	4.38	0.01
21	1.0169	1.45	——	——	——	——	——	6.53	0.01
60 (a)	1.0188	2.20	0.27		——	——	——	7.46	0.00
60 (b)	1.0154	1.70	0.26		——	——	——	5.56	0.01
60 (c)	1.0189	2.17	0.29		——	——	——	7.30	0.00

EXPERIMENT 22.—SAME AS 17, EXCEPT THAT 0.61 PER CT. OF MALIC ACID WAS ADDED; KEPT AT 55° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.88	0.31	0.021	10.34	2.68	——	0.00	1.02
3	1.0040	2.27	——	——	0.18	0.05	——	0.23	0.69
6	1.0024	2.21	——	——	0.12	——	——	0.55	0.61
9	1.0063	2.09	0.28	——	——	——	——	1.08	0.49
14	1.0122	1.90	——	——	——	——	——	1.66	0.33
15	1.0122	1.84	——	——	——	——	——	1.45	0.30
21	1.0097	2.00	——	——	——	——	——	0.47	0.21
60	1.0024	0.60	0.28	——	——	——	——	alkaline	0.00

EXPERIMENT 23.—SAME AS 22, EXCEPT THAT THE TEMPERATURE WAS KEPT AT 70° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.88	0.31	0.021	10.34	2.68	——	0.00	1.02
3	1.0003	2.00	——	——	0.20	0.06	——	0.51	0.46
6	1.0099	1.97	——	——	0.14	——	——	3.75	0.36
9	1.0145	1.87	0.26	——	——	——	——	5.22	0.32
14	1.0170	1.71	——	——	——	——	——	5.75	0.30
15	1.0170	1.61	——	——	——	——	——	5.67	0.28
21	1.0179	1.66	——	——	——	——	——	5.51	0.27
60	0.0133	1.78	0.24	——	——	——	——	3.51	0.21

Experiment 24.—Same as 22 and 23, Except that the Temperature was Kept at 85° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0654	15.88	0.31	0.021	10.34	2.68	——	0.00	1.02
3	0.9996	2.27	——	——	0.15	0.05	——	0.23	0.54
6	1.0003	2.21	——	——	0.12	——	——	0.25	0.54
9	1.0104	2.09	——	——	——	——	——	3.74	0.46
14	1.0153	1.90	——	——	——	——	——	5.04	0.39
15	1.0153	1.84	——	——	——	——	——	4.70	0.38
21	1.0176	2.00	——	——	——	——	——	5.37	0.38
60	1.0105	2.15	0.27	——	——	——	——	0.57	0.35

Experiment 25.—Same Apple Juice Used as in 17; Sterilized and After Standing at 55° F. for Two Months Sterilized Again; Yeast Added; Stored in Quart Bottles at 55° F. First Analysis Given Made at Time of Second Sterilization and the Others Dated from this.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
——	1.0664	15.96	0.35	0.017	12.34	0.44	0.41	0.02	0.51
1	1.0102	4.66	0.37	0.007	1.93	0.08	6.25	0.04	0.47
3	1.0006	2.96	0.35	0.006	0.31	0.00	7.28	0.05	0.47
7	1.0006	2.92	0.39	0.006	——	——	7.10	0.06	0.44
11	1.0009	2.52	——	——	——	——	6.78	0.09	0.41
12	1.0020	2.42	——	——	——	——	6.78	0.09	0.41
18	1.0116	2.53	——	——	——	——	2.58	3.24	0.26
60 (a)	1.0128	2.87	0.37	——	——	——	——	5.96	0.10
60 (b)	1.0190	3.10	0.34	——	——	——	——	5.73	0.21
60 (c)	1.0179	3.07	0.36	——	——	——	——	4.65	0.19

Experiment 26.—Same as 25, Except that Temperature was Kept at 70° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct*	*Per ct.*	*Per ct.*	*Per ct.*
——	1.0664	15.96	0.35	0.017	12.34	0.44	0.41	0.02	0.51
1	1.0011	3.01	0.35	0.007	0.31	0.10	7.25	0.06	0.45
3	1.0005	2.90	0.35	0.007	0.24	0.00	6.10	0.07	0.44
7	1.0029	2.83	0.39	0.006	——	——	5.63	0.96	0.39
11	1.0115	2.32	——	——	——	——	3.52	3.71	0.29
12	1.0128	2.22	——	——	——	——	3.10	4.33	0.27
18	1.0202	2.30	——	——	——	——	0.66	6.87	0.23
60 (a)	1.0238	2.69	0.36	——	——	——	——	8.66	0.26
60 (b)	1.0228	2.65	0.37	——	——	——	——	7.81	0.39
60 (c)	1.0241	2.80	0.36	——	——	——	——	8.48	0.32

EXPERIMENT 27.—SAME AS 25 AND 26, EXCEPT THAT TEMPERATURE WAS KEPT AT 85° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
——	1.0664	15.96	0.35	0.017	12.34	0.44	0.41	0.02	0.51
1	1.0024	3.28	0.34	0.008	0.38	0.01	6.86	0.09	0.48
3	1.0025	3.29	0.35	0.007	0.36	0.00	6.73	0.10	0.46
7	1.0025	3.25	0.37	——	——	——	6.66	0.10	0.45
11	1.0032	2.84	——	——	——	——	6.33	0.11	0.43
12	1.0052	2.74	——	——	——	——	5.43	0.59	0.43
18	1.0101	2.64	——	——	——	——	3.70	2.13	0.38
60 (a)	1.0189	3.70	0.38	——	——	——	——	4.72	0.34
60 (b)	1.0235	3.77	0.35	——	——	——	——	6.03	0.37
60 (c)	1.0212	3.70	0.39	——	——	——	——	4.97	0.34

EXPERIMENT 28.—SAME AS 25, EXCEPT THAT 0.61 PER CT. OF MALIC ACID WAS ADDED.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
——	1.0664	16.57	0.35	0.017	12.34	0.44	0.41	0.02	1.02
1	1.0033	2.76	——	——	0.90	0.07	——	0.20	0.63
3	1.0028	2.12	——	——	0.38	0.00	——	1.47	0.39
7	1.0096	1.95	0.27	——	——	——	——	3.83	0.31
11	1.0102	1.77	——	——	——	——	——	3.78	0.29
12	1.0104	1.68	——	——	——	——	——	3.87	0.28
18	1.0114	1.86	——	——	——	——	——	4.38	0.30
60	1.0173	2.53	0.27	——	——	——	——	6.59	0.21

EXPERIMENT 29.—JUICE PRESSED FROM MIXED FALL AND WINTER APPLES OCTOBER 24, 1900; STORED IN 10-GALLON CASK IN CELLAR.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh.	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
1	1.0040	2.08	——	0.009	0.40	0.02	4.89	0.12	0.45
2	1.0019	1.81	——	0.004	0.23	0.02	4.80	0.31	0.42
3	1.0015	1.89	——	0.003	0.16	0.00	4.80	0.31	0.39
9	1.0011	1.51	——	——	——	——	5.02	0.59	0.07
48	1.0194	1.98	0.47	——	——	——	——	6.74	0.01

EXPERIMENT 30.—DUPLICATE OF 29.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
1	1.0040	2.08	——	0.009	0.40	0.02	4.89	0.12	0.45
2	1.0020	1.82	——	0.005	0.39	0.02	4.76	0.30	0.41
3	1.0015	1.85	——	0.003	0.16	——	4.78	0.26	0.40
9	1.0011	1.51	——	——	——	——	5.02	0.59	0.07
48	1.0175	2.08	0.47	——	——	——	——	6.42	0.01

EXPERIMENT 31.—SAME AS 29, EXCEPT STORED IN FIVE-PINT BOTTLES AT A TEMPERATURE OF 55° F.

Age when analyzed	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	0.9995	1.77	——	0.020	0.27	0.01	5.70	0.25	0.43
3	1.0061	1.79	——	0.004	——	0.00	3.57	2.16	0.34
7	1.0183	1.71	——	0.005	——	——	——	5.96	0.32
9	1.0177	1.51	——	——	——	——	——	6.21	0.30
48 (a)	1.0007	1.43	0.30	——	——	——	——	0.16	0.00
48 (b)	1.0005	0.80	0.27	——	——	——	——	0.16	0.00

EXPERIMENT 32.—SAME AS 31 EXCEPT KEPT AT A TEMPERATURE OF 60° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	1.0043	1.43	——	0.003	0.39	0.00	3.14	2.28	0.02
3	1.0107	1.30	——	0.003	——	——	1.20	4.16	0.01
7	1.0152	1.29	——	0.003	——	——	——	5.37	0.01
9	1.0142	1.30	——	——	——	——	——	5.08	0.01
48 (a)	1.0063	1.35	0.27	——	——	——	——	0.08	0.00
48 (b)	1.0060	1.22	0.27	——	——	——	——	0.16	0.00

EXPERIMENT 33.—SAME AS 31 AND 32, EXCEPT KEPT AT A TEMPERATURE OF 65° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	1.0052	1.24	——	0.003	0.39	0.00	3.14	2.40	0.03
3	1.0121	1.25	——	0.003	——	——	1.20	4.64	0.01
7	1.0135	1.34	——	0.003	——	——	——	4.34	0.01
9	1.0126	1.19	——	——	——	——	——	4.06	0.01
48 (a)	1.0043	1.16	0.28	——	——	——	——	0.06	0.00
48 (b)	1.0046	1.16	0.29	——	——	——	——	0.10	0.00

EXPERIMENT 34.—SAME AS 31–33, EXCEPT KEPT AT A TEMPERATURE OF 70° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	1.0032	1.28	——	0.004	0.39	0.00	3.63	1.74	0.01
3	1.0105	1.32	——	0.004	——	——	1.25	3.83	0.01
7	1.0127	1.27	——	0.004	——	——	——	3.77	0.01
9	1.0116	1.21	——	——	——	——	——	3.51	0.01
48 (a)	1.0030	0.87	0.26	——	——	——	——	0.00	0.00
48 (b)	1.0030	0.72	0.26	——	——	——	——	0.00	0.00

EXPERIMENT 35.—SAME AS 31–34, EXCEPT KEPT AT A TEMPERATURE OF 75° F.

Age when analyzed.	Specific gravity	Solids.	Ash.	Nitrogen.	Reducing. sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	1.0071	1.22	——	0.005	0.34	0.00	2.61	2.95	0.01
3	1.0141	1.29	——	0.004	——	——	0.59	5.20	0.01
7	1.0122	1.21	——	0.004	——	——	——	3.65	0.01
9	1.0107	1.31	——	——	——	——	——	2.86	0.01
48 (a)	1.0040	0.86	0.26	——	——	——	——	0.00	0.00
48 (b)	1.0035	0.67	0.23	——	——	——	——	alkaline	0.00

EXPERIMENT 36.—SAME AS 31–35, EXCEPT KEPT AT A TEMPERATURE OF 80° F.

Age when analyzed.	Specific gravity.	Solids.	Ash.	Nitrogen.	Reducing sugars.	Sucrose.	Alcohol by weight.	Volatile acid as acetic.	Fixed acid as malic.
Mths.		*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Fresh	1.0615	13.97	0.27	0.029	9.64	3.01	0.00	0.02	0.54
2	1.0012	1.25	——	0.005	0.32	0.00	5.27	0.90	0.01
3	1.0118	1.25	——	0.002	——	——	0.20	3.64	0.01
7	1.0093	1.18	——	0.002	——	——	——	1.60	0.01
9	1.0080	1.29	——	——	——	——	——	1.17	0.01
48 (a)	1.0039	0.86	0.25	——	——	——	——	0.00	0.00
48 (b)	1.0039	0.62	0.26	——	——	——	——	alkaline	0.00

REPORT

OF THE

Department of Entomology.

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REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

THE LIME-SULPHUR-SODA WASH FOR ORCHARD TREATMENT*

P. J. Parrott, S. A. Beach and H. O. Woodworth.

SUMMARY.

This bulletin gives the results of the first year's experiments to determine to what extent the lime-sulphur-caustic soda wash may be used in place of the bordeaux-arsenical mixtures for orchard treatment, and the value of this wash for the control of the San José scale.

The results are as follows:

Applications of the wash for the treatment of the scale gave somewhat variable results, which indicate that the various preparations were not always equally destructive to the scale. Some treatments gave satisfactory results, which show that an efficient spray may be prepared in the manner described. For this reason and because this method of preparing a sulphur wash is especially adapted to use by smaller orchardists, further experiments are to be made to test the wash and to devise methods by which all preparations may be made equally efficient.

In the treatment of apple trees the wash proved very efficient in preventing injuries by early spring leaf-eating caterpillars, as the bud moth and case bearer (*Tmetocera* and *Coleophora* sp.). An examination of samples of foliage shows that the average percentage of leaves from treated trees having caterpillar injuries is 13.9 per ct. and from untreated trees 71.7 per ct., proving that upon the sprayed trees there were 57.8 per ct. less worm-eaten leaves because of the treatment.

*Reprint of Bulletin No. 247.

Comparative tests of the sulphur wash and the bordeaux-arsenical mixtures for the control of the codling moth demonstrated that the latter treatment is more effective. The average percentage of wormy apples from the trees treated with the bordeaux-arsenical mixtures is 15.3 per ct., and from the trees spayed with lime-sulphur-soda wash 36.7 per ct., showing that there were 21.4 per ct. less wormy apples upon the trees sprayed with the bordeaux-arsenical mixtures. No data were obtained upon the effects of applications of sulphur wash upon the hibernating larvæ.

Because of the absence of peach leaf curl, apple scab and other diseases in the experimental orchards no results were obtained as to the value of the sulphur wash for these diseases. Future experiments are necessary to determine the value of this treatment for these and other orchard diseases, and to what extent it may be employed in place of the usual applications of the bordeaux-arsenical mixtures.

INTRODUCTION.

One of the significant results of the lime-sulphur-salt experiments, conducted in 1902 by this Station, was that the apples upon the sprayed trees in the Stevenson* orchard were practically free from scab while those of the checks were badly affected. The only satisfactory explanation for the superior condition of the fruit of the former was that the applications of the sulphur wash during the dormant season had prevented scab attack. In other experiments it had been conclusively demonstrated that similar treatment had efficiently controlled both scale and peach leaf curl.

From these results it was clearly apparent that the sulphur sprays have considerable fungicidal value and therefore have a greater range of usefulness and were more efficient in the East than had heretofore been suspected. But to what degree these sprays can be profitably used in eastern orchards, aside from the treatment of scale and leaf curl, has not been determined.

In view of this fact that it was considered desirable to undertake investigations to ascertain to what extent treatment with a sulphur wash during the dormant season could be depended

*Bulletin 228 of this Station, p. 405.

upon to take the place of the usual applications of bordeaux mixture and arsenical sprays for scab and other diseases, and early spring leaf-eating insects. It was also desired by Mr. V. H. Lowe to continue his investigations with his modification of the lime-sulphur-salt wash, in which caustic soda was substituted for the salt in the regular formula and used to prepare the wash, in place of external heat.

Accordingly experiments were planned jointly by Mr. Lowe and Prof. S. A. Beach, to determine to what extent the lime-sulphur-caustic soda wash could be used in place of the common sprays in orchard treatment, and its value for the control of the scale.

The execution of these plans was entrusted to Messrs. H. O. Woodworth and O. M. Taylor, who superintended the spraying of the orchards and made frequent observations upon the results of the treatment. Mr. V. A. Clark made the final examination of the yields in the Yorktown orchard and reported his results in Table 1. Owing to the death of Mr. Lowe the writing of this bulletin largely devolved upon Mr. P. J. Parrott, his successor, who has in charge the entomological work of this investigation.

Acknowledgments are due to Messrs. White & Rice of Yorktown, and Mr. Albert Wood and Mr. Geo. Callard of Carlton Station, in whose orchards these experiments were conducted and who heartily coöperated in this work.

OUTLINE OF THE EXPERIMENT.

THE PLAN.

The experiment as planned consisted of a series of tests to determine the comparative merits of (1) one application of the sulphur wash during dormant season, (2) one application of the sulphur wash during dormant season supplemented with the remainder of the regular line of treatment with the bordeaux-arsenical mixtures, and (3) the usual applications of the bordeaux-arsenical mixtures for the treatment of common orchard pests. By the aid of abundant checks it was expected, by using this method of treatment, to obtain data upon the following points: (1) The value of the sulphur wash for scale and other insects, and for plant diseases; (2) the comparative values of the sulphur wash and bordeaux-arsenical mixtures for orchard spraying; and (3) to what extent one application of the sulphur wash could be depended upon to take the place of one or more applications of the bordeaux-arsenical mixtures.

In conducting the field work, blocks of bearing apple, peach, pear and plum, secured for the experiments, were divided into four sections, the varieties being representative of all. These sections were treated as follows: Section No. I, sprayed once with the lime-sulphur-soda wash; Section No. II, sprayed once with the sulphur wash before the opening of the buds and twice after the appearance of the leaves with the bordeaux-arsenical mixtures; Section No. III, check, no treatment; Section No. IV, sprayed three times with bordeaux mixture containing an arsenical poison, once before and twice after the appearance of the leaves.

LOCATION OF ORCHARDS.

To carry out these plans, coöperative experiments were arranged with a number of the fruit-growers of this State. These experiments were conducted under the direct supervision of a member of the Station staff, who directed the spraying operations and kept records of the details of the work and the results of the treatment.

The orchards in which the experiments were made are situated in Westchester county, near Yorktown; in Ontario county, near Geneva; and in Orleans county, near Carlton Station. The number of trees treated was 1,440, consisting of 451 large apple, 245 plum, 338 pear, 375 peach, 26 quince and 5 cherry.

These orchards, with the exception of No. 1 at Carlton Station (which has been somewhat neglected, especially in the treatment for insects and diseases) have received careful attention, and have been given the usual sprayings with bordeaux mixture containing an arsenical poison.

The San José scale was present in all of the orchards, with the exception of No. 2 at Carlton Station. In the Geneva and Carlton Station No. 1 orchards the scale was not abundant, except upon a few trees. None of these have ever been treated for this pest. The Yorktown orchards have been known to be infested for a number of years, and have been treated in part with hydrocyanic acid gas and petroleum. The scale was well distributed among all the varieties. A goodly number of the trees were much incrusted with the scale, and many of the remaining ones were infested to a lesser degree.

The number and variety of the trees and their conditions with respect to scale furnished an excellent opportunity to work out the problems in view. In each experiment with each kind of fruit, abundant checks were reserved. In selecting these the aim was that the trees should be representative of the varieties and of similar condition with respect to scale and pest treatment as those under experiment.

THE PREPARATION OF THE SPRAYS.

The Bordeaux-Arsenical Mixture.

Copper sulphate	5 lb.
Quicklime	$3\frac{1}{3}$ to 5 lbs.
Water	50 gal.
Paris green	½ lb.

The bordeaux mixture was prepared by the common method. In the treatment of apple trees the paris green was used in the amount stated; but for peach, plum and pear, only one-quarter of a pound of the poison was used for this quantity of spraying mixture. The paris green was added to the freshly-prepared bordeaux mixture.

The Lime-Sulphur-Caustic Soda Wash.

Lime	30 lb.
Sulphur	15 lb.
Caustic soda	4–6 lb.
Water	50 gal.

The formula used in the experiments was essentially as above, though slight changes in proportions were made in some cases.

In preparing the wash, the lime was started to slake with six gallons of water; and while it was slaking, the sulphur, which had just previously been made into a thin paste with hot water, was added and thoroughly mixed in with the slaking lime. To prolong the boiling of the wash, the caustic soda was then added, with water as needed, and the whole mixture was kept thoroughly stirred. As soon as the chemical action had ceased, the required amount of water was added, when the mixture was ready for use.

Aside from the heating of the water, the cooking of the wash was done in a tub or half barrel, and took from ten to twenty minutes. In some preparations, especially when hot water was used to start the slaking of the lime, not all of the stated amount of caustic soda was employed, but six pounds was the maximum.

CONDITIONS.

The work of applying the sulphur wash commenced March 25 and continued till April 29. During the early applications the weather was bright and spring like, with light winds and occasional showers. Towards the last the weather changed and became cold and cloudy with frequent rains. Much difficulty was experienced at this time in spraying the larger trees. Rains occurred March 28, 30, 31 and April 6, 7, 8, 9, 10, 11, 14, 15, and 16. As a whole, the weather during the time of spraying was a severe test of the wash.

In applying the wash the trees were sprayed once carefully, and as soon as the application was dry, another was made, the spray being directed only upon the parts of the trees that had escaped the first treatment. Vermorel nozzles with fine apertures were employed in all of the operations.

The weather for the four weeks immediately following the last spraying with the sulphur wash was very dry. The precipitation at Geneva for May was .23 inches as compared with an average of 2.51 inches for the same months in the four preceding years.

In using the bordeaux-arsenical mixtures applications were made as follows: (1) As the leaf buds commenced to appear green at the tips; (2) just after the blossom fell; and (3) from ten to fourteen days after the second treatment. As previously explained, the first application was always omitted in the treatment of Section II in all orchards. In applying the spray the trees were sprayed once carefully and did not receive further treatment except as provided for in the regular order of spraying.

GENERAL RESULTS.

In planning these experiments it was the aim to obtain data upon the relative values of the sprays employed for the treatment of important insect and fungous pests of the orchard. Results of these sprays upon pests which are controlled by treatment during the dormant season were especially desired. Owing to the location of some of the orchards and the peculiar weather conditions which prevailed during the growing season the number of pests upon which an opportunity was given to make satisfactory tests was disappointingly small. This was especially true of the plant diseases, which were very little destructive this year. Very satisfactory results were obtained upon the San José scale, the codling moth, the bud moth and case bearers, especially the two latter, which are discussed under separate headings.

RESULTS ON SCALE.

The Yorktown orchard.—A careful examination of the orchards at Yorktown was made from September 21 to 23, to determine the effects of the sulphur wash upon the scale. The results upon the apple trees indicate that the numbers of the scale had been greatly reduced. In comparison with the checks the treatment had apparently destroyed from 60 to 80 per ct. of the scales. On a number of the twigs and branches of three trees young live scales were quite abundant. Upon these trees the wash did not appear to be so efficient. Their condition indicated that the different preparations of the wash were not always equally effective. It was quite apparent in the course of inspection that the trees that were much incrusted with scale and had considerable rough bark were the least affected by the treatment. While these trees did not differ from others in an appreciable degree with respect to the condition of the bark, they were among the worst infested trees of the orchard. Undoubtedly the dense layers of scale, together with the rough bark, contributed to these unfavorable results. The fruit upon the sprayed trees was, as a rule, very clean, although there were individual trees that had quite a few specimens of fruit spotted with scale. The records of five trees show that from yields of 1,200 to 4,000 apples there were respectively from 12 to 30 infested specimens. The infestation of the foliage was very slight.

Upon the peach, plum, and pear trees the percentage of scales killed, while varying with individual trees, averaged higher than upon the apples in the same vicinity. The fruit and foliage of the peach and plum trees were unaffected while about three to five per ct. of that on the pear trees was marked with scale. The wash was most effective upon the moderately infested trees, where a large proportion of the scales was destroyed. The trees of these varieties were small and possessed smooth bark; and for these reasons were undoubtedly better treated.

The Geneva and Carlton Station No. 1 orchards.—In these orchards the best results with the wash were obtained. As indicated before, none of these trees were much infested with scale. The scales as a rule were few and widely distributed, and were confined to twigs and small branches in the upper parts of the trees. In no case were the scales upon the large branches where protection would be furnished by rough bark. In the Geneva orchard the scales seemed to be entirely destroyed by the treatment. Frequent examinations were made during the summer by Mr. Taylor who reports that he was unable to find a living scale upon any of the treated trees. Quite similar results were obtained in the Carlton Station No. 1 orchard. It should be stated that in preparing the wash for this orchard steam was employed for about ten minutes to heat the water to start the slaking of the lime, and to dissolve the soda. The most satisfactory demonstration of the insecticidal value of the wash was shown by the condition of one apple tree, which was the worst infested one in the orchard. On October 20 this tree was carefully examined. After considerable searching a few live scales were found on a number of branches. The treatment had cleaned the branches of most of the scales. The scales that still adhered were for the most part dead, and upon being scraped with a knife blade fell to the ground as dry, scurfy matter. Out of 7,784 apples gathered from 8 trees sprayed with the wash there were only 8 infested specimens.

RESULTS ON CODLING MOTH.

The results upon the comparative values of the sulphur wash and the bordeaux-arsenical mixture upon this insect were obtained in the Yorktown and Carlton Station orchards. Owing to the differences in their conditions and past treatment, each orchard will be considered separately.

Experiments at Yorktown.—This orchard is composed of old trees, which are of a large size. These have in the past received very careful attention with respect to cultivation and spraying. The leading varieties are Baldwin, Gravenstein, Nonesuch and Roxbury. For the experiment there were reserved 276 trees which were treated as follows: 71, Section I, treated with lime-sulphur-soda wash; 60, Section II, lime-sulphur-soda wash and bordeaux mixture with arsenical poison; 64, Section III, check; and 81, Section IV, bordeaux mixture with an arsenical poison. The treatment was made upon the dates previously given. On October 12 to 16, the apples from a number of trees were counted to determine the relative amounts of sound and wormy fruit. As the Baldwins are greater in numbers and are represented in all of the treatments, the count was largely confined to this variety. The records of the yields of eighteen Baldwins are given in the accompanying table:—

Table No. I.—Yield of Sound, Wormy and Diseased Apples, Under Different Treatments, at Yorktown.

Number of section and tree.		Yield of Picked Apples.						Yield of Windfalls.					
		Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.	Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.
		No.	No.	No.	No.	No.		No.	No.	No.	No.	No.	
Sec. I.	Tree 1	1,485	325	135	28	1,973	23.3	577	57	385	26	1,045	42.3
One application of	2	1,862	670	384	33	2,949	35.7	830	63	415	21	1,329	36.0
the lime-sulphur-	3	2,646	627	320	50	3,643	26.0	400	29	261	14	704	41.2
soda wash.	4	1,663	272	241	96	2,272	22.6	1,410	93	330	40	1,873	22.6
	5	510	57	57	45	669	17.0	289	31	89	17	426	28.2
		Average per ct. wormy					24.9	Average per ct. wormy					34.1
Sec. II.	Tree 1	723	0	64	0	787	8.1	153	3	13	2	171	9.4
One application of	2	3,598	25	151	20	3,794	4.6	423	30	190	17	660	33.3
sulphur wash and	3	2,667	19	130	88	2,904	5.1	740	12	56	21	829	8.2
two of bordeaux-	4	1,114	10	94	26	1,244	8.4	175	9	77	30	291	29.6
arsenical mixture.	5	3,112	114	206	87	3,519	9.1	1,062	28	190	37	1,318	16.6
		Average per ct. wormy					7.1	Average per ct. wormy					19.4
Sec. III.	Tree 1	1,500	136	108	36	1,780	13.7						
Check, no treat-	2	266	38	32	6	342	20.5						
ment.	3	386	22	37	5	450	13.1						
		Average per ct. wormy					15.8						
Sec. IV.	Tree 1	1,939	4	28	7	1,978	1.6						
Three applications	2	569	0	7	4	580	1.2						
of bordeaux-	3	200	0	4	2	206	1.9						
arsenical	4	2,400	12	14	14	2,440	1.1						
mixture.	5	1,950	6	19	19	1,994	1.3						
		Average per ct. wormy					1.4						

In examining this table it will be seen that the average percentage of wormy apples (picked) from Section I is 24.9; Section

II, 7.1; Section III, 15.8; and from Section IV, 1.4. As the orchard has in the past been carefully sprayed the proportion of wormy fruit is low, as would be expected. The sound fruit from trees treated with bordeaux-arsenical mixture averaged 98.6 per ct. as compared with 75.1 per ct. of sound fruit from trees treated with the sulphur wash. Thus there was, upon the trees treated with the bordeaux-arsenical mixture, 23.5 per ct. less wormy apples than upon the trees sprayed with the sulphur wash. The percentage of wormy apples from trees sprayed with the sulphur wash is higher than that of the checks. This difference is undoubtedly due to the variation of individual trees in the amount of infestation, irrespective of the treatment; for it is clearly evident from the results obtained with the sulphur wash in this and other orchards that this treatment gives no protection to the fruit from the codling moth. The same explanation may be given for the results obtained from the trees in Section II, which were treated once with the sulphur wash and twice with the bordeaux-arsenical mixtures, in comparison with Section III, treated entirely with the bordeaux-arsenical mixtures. The difference in the results of these two sections seems to be due to the variation of individual trees in the amount of the infestation of the fruit rather than to differences in treatment.

The superior results from the bordeaux-arsenical mixture are not surprising, when one considers the habits of the codling moth. If the infestation had been greater, more marked contrasts in the results of the two sprays would have been expected. It seems to be clearly indicated by the experiments that an arsenical spray must be depended upon for the control of the codling moth. The effects of applications of a sulphur wash upon the hibernating larvæ were not determined.

Experiments at Carlton Station.—This orchard consists almost entirely of the variety Baldwin. The trees are about thirty years of age, and have been somewhat neglected with respect to treatment with spraying mixtures. In this experiment 165 trees were used. With the exception of five trees reserved for checks, this number was divided evenly for treatment as outlined in the preceding experiment. On October 20-22 a count was made to determine the effects of the treatments upon the codling moth.

The examination was confined entirely to the fruit of Section I, treated with the lime-sulphur-soda wash, and Section IV, treated with the bordeaux-arsenical mixtures. The results of the examination are given in the following table:

TABLE No. II.—YIELD OF SOUND, WORMY AND DISEASED APPLES, UNDER DIFFERENT TREATMENTS, AT CARLTON STATION, ORCHARD 1.

NUMBER OF SECTION AND TREE.		Yield of Picked Apples.						Yield of Windfalls.					
		Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.	Sound.	Wormy on end.	Wormy on side.	Scabby.	Total.	Per ct. wormy.
		No.	No.	No.	No.	No.		No.	No.	No.	No.	No.	
SEC. I. Tree	1	286	140	11	0	437	34.6	39	112	3	0	154	74.7
One application of	2	40	28	5	0	73	45.2	13	18	0	0	31	58.1
the lime sulphur	3	198	262	42	0	502	60.6	81	136	8	0	225	64.0
soda wash.	4	76	93	0	0	169	55.0	36	182	13	0	231	84.4
		Average per ct. wormy					48.8	Average per ct. wormy					70.3
	5	10	68	9	0	87	88.5	78	142	13	0	233	66.5
	6	862	312	42	0	1,216	29.1	45	96	20	0	161	72.1
	7	312	349	5	0	666	53.2	59	362	85	0	506	88.4
	8	1,873	496	66	8	2,443	23.0	114	486	50	0	650	82.5
		Average per ct. wormy					48.4	Average per ct. wormy					77.3
SEC. IV. Tree	1	59	15	4	0	78	24.4	52	48	7	0	107	51.4
Three applications	2	412	161	23	0	596	30.9	41	112	18	0	171	76.0
of the bordeaux-	3	895	417	51	2	1,365	34.3	119	296	15	0	430	72.3
arsenical mixture.	4	1,780	452	18	0	2,250	20.9	205	305	42	1	553	62.8
	5	268	148	3	0	419	36.0	129	116	24	0	269	52.1
		Average per ct. wormy					29.3	Average per ct. wormy					62.9

The wormy apples (picked) from Section I averaged 48.6 per ct. and from Section IV, 29.3 per ct. The sound fruit from trees treated with the bordeaux-arsenical spray is 70.7 per ct. and from trees sprayed with the sulphur wash 51.4 per ct. Thus there was upon the trees sprayed with the bordeaux-arsenical mixture 19.3 per ct. less wormy apples than upon the trees sprayed with the sulphur wash. The results of this experiment agree very closely with those obtained in the Yorktown orchard, and further emphasize the superiority of the bordeaux-arsenical mixture for this pest.

RESULTS ON EARLY LEAF-EATING CATERPILLARS.

An examination of the Carlton Station (No. 1) orchard on May 5, showed that there was a marked contrast in the appearance of the foliage of the checks and of the trees treated with the sulphur wash. The leaves of the treated trees appeared to be more healthy and abundant. Upon close inspection it was found that the principal cause of this difference was that the early spring leaf-eating caterpillars had been much more destructive to the foliage of the check trees.

In the past this orchard had been somewhat neglected, and these insects seemed to have had full sway as indicated by their work upon the untreated trees. These results were entirely unexpected, and were a great surprise to the observers. To those on the ground there was forced the conclusion that the treatment with the sulphur wash had greatly reduced the numbers of these insects. To obtain data upon the condition of the foliage at that time Mr. Taylor collected samples of leaves which were representative of the sprayed and unsprayed trees, and after a careful examination reported the results given in the following table:

TABLE No. III.—A RECORD OF THE CONDITIONS OF FOLIAGE UPON SPRAYED AND UNSPRAYED TREES.

TREATMENT OF TREES.	Leaves.	Leaves not injured.	Leaves injured.	Leaves not injured.	Leaves injured.	Larvæ of bud moth on leaves.	Case bearers on leaves.
	No.	No.	No.	Per ct.	Per ct.	No.	No.
Sprayed	96	84	12	87.5	12.5	0	6
Check	120	31	89	25.8	74.2	8	35

On June 9, Prof. Beach and Mr. Taylor again visited the orchards to make further observations. The condition of the trees was much the same except that the foliage of the unsprayed trees did not appear to be so completely worm-eaten as before, because of the appearance of new leaves which at this time were not much affected by the insects. The uninjured leaves were as a rule of recent appearance. Representative clusters of leaves and fruits were gathered from treated and untreated trees and examined as before. The results of the examination are given in the accompanying tables:

Table No. IV.—A Record of the Conditions of the Foliage of Sprayed[1] and Unsprayed[2] Trees.

Tree Sprayed With Lime-Sulphur-Salt Wash.				Tree Not Sprayed.			
Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.	Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
9	7	2	22.2	3	0	3	100.0
9	9	0	0.0	4	2	2	50.0
9	9	0	0.0	5	0	5	100.0
10	10	0	0.0	5	3	2	40.0
6	6	0	0.0	3	0	3	100.0
8	8	0	0.0	6	3	3	50.0
7	7	0	0.0	4	4	0	0.0
9	9	0	0.0	5	4	1	20.0
7	7	0	0.0	6	6	0	0.0
9	8	1	11.1	7	6	1	14.3
6	5	1	16.7	4	1	3	75.0
6	6	0	0.1	4	2	2	50.0
9	7	2	22.2	6	2	4	66.7
6	6	0	0.0	4	1	3	75.0
5	5	0	0.0	3	0	3	100.0
5	5	0	0.0	6	2	4	66.7
7	5	2	28 6	7	1	6	85.7
7	7	0	0.0	7	6	1	14.3
6	6	0	0.0	8	1	7	87.5
5	2	3	60.0	5	1	4	80.0
7	6	1	14.3	8	5	3	37.5
5	4	1	20.0	11	1	10	90.9
11	8	3	27.3	7	2	5	71.4
Average percentage of leaves eaten.			9.7	Average percentage of leaves eaten.			59.8

Table No. V.—A Record of the Conditions of the Foliage of Sprayed[3] and Unsprayed[4] Trees.

Tree Sprayed With Lime-Sulphur-Soda Wash.				Tree not Sprayed.			
Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.	Leaves in cluster.	Leaves free.	Leaves eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
5	1	4	80.0	8	2	6	75.0
6	6	0	0.0	6	1	5	83.3
6	6	0	0.0	7	0	7	100.0
9	9	0	0.0	3	0	3	100.0
6	6	0	0.0	7	2	5	71.4
8	8	0	0.0	6	0	6	100.0
7	7	0	0.0	7	1	6	85.7
8	4	4	50.0	6	3	3	50.0
8	7	1	12.5	9	0	9	100.0
7	6	1	14.3	7	0	7	100.0
7	5	2	28.6	9	6	3	33.3
8	2	6	75.0	8	3	5	62.5
7	4	3	42.9	9	1	8	88.9
5	4	1	20.0	6	0	6	100.0
10	7	3	30.0	8	3	5	62.5
7	7	0	0.0	7	0	7	100.0
7	7	0	0.0	4	1	3	75.0
4	4	0	0.0	9	0	9	100.0
5	5	0	0.0	8	2	6	75.0
5	3	2	40.0	7	0	7	100.0
7	6	1	14.3	7	4	3	42.9
Average percentage of leaves eaten			19.4	Average percentage of leaves eaten			81.2

[1] Tree 4, Section I. [2] Tree 3, Section IV. [3] Tree 6, Section I. [4] Tree 2, Section IV.

TABLE No. VI.—A RECORD OF THE CONDITIONS OF THE FRUIT OF SPRAYED[1] AND UNSPRAYED[2] TREES.

Tree Sprayed With Lime-Sulphur-Soda Wash.				Tree not Sprayed.			
Fruits in cluster.	Fruits free.	Fruits eaten.	Proportion eaten.	Fruits in cluster.	Fruits free.	Fruits eaten.	Proportion eaten.
No.	No.	No.	Per ct.	No.	No.	No.	Per ct.
1	1	0	0.0	2	0	2	100.0
2	2	0	0.0	2	2	0	0.0
4	4	0	0.0	2	2	0	0.0
1	1	0	0.0	3	0	3	100.0
1	1	0	0.0	1	0	1	100.0
3	3	0	0.0	1.	1	0	0.0
2	2	0	0.0	4	3	1	25.0
4	4	0	0.0	1	1	0	0.0
3	0	3	100.0	4	1	3	75.0
3	3	0	0.0	1	0	1	100.0
1	1	0	0.0	2	1	1	50.0
Average per ct. of fruit eaten 9.				Average per ct. of fruit eaten 50.			

[1] Tree 4, Section I. [2] Tree 3, Section III.

The total number of leaves examined is 802, of which 406 were from trees treated with the sulphur wash and 396 from untreated trees. The number of fruits examined is 48, of which 25 were taken from sprayed and 23 from unsprayed trees. The worm-injured leaves from the sprayed trees averaged 13.9 per ct. and from the unsprayed trees 71.7 per ct. The worm-injured fruit from the sprayed trees averaged 9 per ct. and from unsprayed trees 50 per ct. Thus of the number examined there was 57.8 per ct. less worm-eaten leaves and 41 per ct. less worm-eaten apples from the sprayed lot than from the unsprayed. Judging from the appearance of the foliage at the time of the examinations it is believed that these figures closely represent the conditions of the leaves of the sprayed and unsprayed trees.

In the Carlton Station No. 2, orchard which belongs to Mr. Albert Wood, 74 apple trees, consisting of the varieties Twenty-Ounce and Roxbury Russet, were used for the experiment. These trees were old and of a very large size. During the past ten years they have been thoroughly sprayed for insects and fungous pests. Because of this careful treatment, the case-bearer and bud-moth were not numerous enough to be injurious. For this reason no results were obtained upon the value of the sulphur wash for these pests. There were no evidences of the work of the codling moth upon any of the trees. Because of this no count was made of the fruit. The weather conditions prevailing during the growing season were very unfavorable for the apple scab. For this reason there was no evidence of this disease in the orchard, and consequently no opportunity was given to determine the comparative values of the sulphur wash and the bordeaux mixture for the treatment of this trouble.

RESULTS ON PLANT DISEASES.

The season was remarkable for the absence of important fruit diseases. During the early part of the growing season there was a protracted drouth, which was succeeded on June 7 by cold, wet weather. These conditions were unfavorable for the development of orchard diseases. For this reason the experiments undertaken to determine the comparative merits of the sulphur wash and bordeaux mixture as fungicides gave no satisfactory results. Apple scab, which was so destructive the year before, was not sufficiently abundant to give conclusive evidence upon the merits of the different sprays. Likewise the work undertaken for the peach leaf curl, sooty blotch, brown rot, etc., gave inconclusive results. It is intended to continue these experiments until conclusive results are obtained.

DISCUSSION OF RESULTS AND CONCLUSIONS.

The experiments recorded in this bulletin represent the first season's work to determine to what extent the lime-sulphur-caustic soda wash may be used in the place of the usual applications of the bordeaux-arsenical mixture for orchard treatment and its value for scale control. It will be remembered that extensive tests conducted by this Station in 1902 demonstrated that the lime-sulphur-salt wash was a safe and reliable remedy for the scale. Likewise experiments conducted in this and other states have shown that this wash may to some degree prevent apple scab, pear psylla, and peach and pear mites. But its value for these latter and other important orchard pests has not been sufficiently determined to warrant its recommendation in place of recognized remedies.

In view of the fact that the scale is becoming more widely distributed, and sulphur sprays are being more generally used, there is need of more data as regards to the efficiency of sulphur washes for other pests than the scale and its range as a combined insecticide and fungicide. It was for this purpose that the present experiment was planned. In this year's work considerable progress has been made in the knowledge of the limits of the profitable use of sulphur sprays in the East. Because of the demand for information upon the use of lime-sulphur soda wash, the present bulletin, which contains the important results of the investigation and directions for the preparation of sulphur washes has been published as a preliminary report of the progress of the work to date.

The conclusions drawn from the year's work are as follows:—

The experiments with the lime-sulphur-caustic soda wash indicate that the wash prepared in this manner may not give as uniform results for scale treatment as the common lime-sulphur-salt wash, prepared by external heat. The difficulty of preparing an unvarying wash by this method seems to be due to variations in the quality of lime and caustic soda, and the quantity of water employed in the slaking of the lime. As some applications have proven very efficient and as this method of preparing a sulphur spray is a convenient one for small orchardists, further experiments are to be carried on to test this wash and to devise methods by which all preparations of it may be uniformly destructive to the scale.

One application of the lime-sulphur-soda wash to apple trees during the dormant season greatly reduced injuries by early spring leaf-eating caterpillars (*Tmetocera* and *Colcophora* sp.). Upon the sprayed trees 13.9 per ct. of the leaves and 9 per ct. of the apples were worm-injured; while upon the unsprayed trees 71.7 per ct. of the leaves and 50.0 per ct. of the fruits were worm-injured.

In the comparative tests with one application of the sulphur wash during dormant season and the usual treatment with the bordeaux-arsenical mixtures for the control of the codling moth it was shown that the latter treatment was much more effective. The average percentage of wormy apples from trees sprayed with the bordeaux-arsenical mixtures is 15.3 and from trees sprayed with the lime-sulphur-soda wash 36.7. The results indicate that the sulphur wash has no effect in preventing injuries to the fruit by this pest. The effects of the wash upon the hibernating larvæ were not determined.

Owing to the absence of apple scab in the experimental orchards no opportunity was given to determine the value of the sulphur wash for this disease. As it is desirable to obtain more data of the value of this treatment for this disease the experiment is to be continued until conclusive results are obtained. For the same reason as for the scab the results of the sulphur wash upon other plant diseases were inconclusive. Aside from peach leaf curl, the value of surphur sprays for orchard plant diseases remains undetermined and requires further investigation.

To what extent it is advisable to use a sulphur spray in place of the bordeaux-arsenical mixtures remains undetermined. Before any satisfactory conclusion can be drawn upon the desirability of a change of sprays in the first spring treatment of the apple, cherry, pear and plum, data are needed upon the value of the sulphur wash for apple scab, fruit rot and pear scab.

In case of the peach one application of the sulphur wash during dormant season may be used in place of the usual treatment with bordeaux mixture for the control of scale and leaf curl.

THE LIME-SULPHUR-SALT WASH.

The formula and directions for preparing the lime-sulphur-salt wash are as follows:

FORMULA.

Lump lime	15 pounds.
Flowers of sulphur	15 pounds.
Salt	15 pounds.
Water	50 gallons.

Place the lime in a kettle, or in a vat if steam is used, and slake it with hot water so that it forms an even white paste. Now add enough water to reduce the lime paste to a thin whitewash. The sulphur and salt are then added and should be thoroughly stirred in. If the mixture is not already boiling, bring it to this point and allow it to boil for one hour. If the wash is prepared in an iron kettle it will be necessary to add a bucket of water now and then to replace that lost in the boiling process, and to stir the mixture frequently to prevent the burning and caking of the materials upon the sides of the vessel. After one hour's boiling, enough hot water should be added to make the required amount of mixture, or if cold water is used the proper proportion should be added and the wash again brought to the boiling point. The wash is now ready for use. It should then be emptied into a spraying barrel, being strained through common wire screening, and if possible, applied while hot to the trees. Applications should be made during dormant season.

The salt may be omitted. Experiments conducted this past summer indicate that washes prepared without the salt have given as satisfactory results as preparations containing it. Some think that it makes the wash more adhesive, and others believe that preparations containing it are more likely to injure the buds. These are points that are not satisfactorily determined. If preparations without it are equally efficient there seems no necessity for using the salt. Some orchardists add the dry sulphur and salt before the slaking of the lime or sift it in dry, or add it as a paste during the slaking process. The mixture made by either of these methods seems to give satisfactory results, but it is believed that prepared as directed above there is less coarse sediment. Recent experiments indicate that one-half hour's boiling is sufficient but till more extensive tests have been made the full amount of time is advised. The mixture should be boiled till it is of a brick red color, and when allowed to settle appears as a brownish or yellowish-green liquid.

Use good fresh stone lime, which when slaked forms an even paste free from grit and dirt. The Ohio white lump lime makes a first class wash, and some grades of local lump lime have been found satisfactory. Flowers of sulphur, and light and heavy flour of sulphur may be used. The stock salt is the grade used.

THE LIME-SULPHUR-CAUSTIC SODA WASH.

FORMULA.

Lump lime	30 pounds.
Flowers of sulphur	15 pounds.
Commercial caustic soda	4-6 pounds.
Water	50 gallons.

Place the full quantity of lime in the kettle or barrel, or whatever the receptacle may be, and start it to slake with water, using enough to prevent the lime from being air-slaked, and not enough to drown it. As soon as the boiling action commences, add the sulphur, which has just previously been made into a paste with water. Stir this in thoroughly and pour in water in small quantities, to keep the mixture in the form of a rather thin paste. After the slaking of the lime, then add the caustic soda, in lots of about two pounds, at short intervals, and stir till the soda is dissolved. As soon as the chemical action has ceased, dilute the mixture with cold water to make the required amount. The time of cooking will be shortened by using warm water in slaking the lime, and in making the sulphur into a paste. This wash is advised for experimental purposes, or when it is not possible to use the sulphur wash prepared by external heat.

Use the same grades of lime and sulphur, flowers of sulphur preferably, as for the lime-sulphur-salt wash. For extensive spraying, purchase from wholesale druggists the commercial caustic soda, put up in fifty pound cans. Upon exposure to the air, the caustic soda absorbs moisture and greatly increases in weight. Odd amounts of the soda may be kept dry in covered Mason jars. To prepare small quantities of the wash one may use any of the common soda lye brands, as sold by grocers.

FALL SPRAYING WITH SULPHUR WASHES.*

P. J. PARROTT AND F. A. SIRRINE.

SUMMARY.

This bulletin contains the details of the first year's experiment by this Station to determine the effects of fall applications of various sulphur washes upon fruit and leaf buds, and the comparative values of these sprays for San José scale treatment. The tests were made upon standard varieties of fruits in orchards located at Queens and Geneva. The important results are as follows:

In Orchard I, which was free of scale, the applications caused a diminution in the amount of bloom and foliage of peaches and plums, which varied according to the spray employed, the lime-sulphur wash proving the least destructive. With the advance of the summer there was a marked increase in the quantity of new growth and foliage upon these trees. The unsprayed peaches produced normal yields of blossoms and leaves. The maturing of the fruit was accompanied by a decline in the condition of these unsprayed trees and many of them failed to survive the summer. The unsprayed plums produced a small crop of fruit and made an abundant new growth. With the exception of the fruit yields there was ultimately very little difference in the appearances of the sprayed and unsprayed plums.

In Orchard II, which was infested with scale, the plums lost from 10 to 50 per ct. of their blossoms and had slight injuries to the leaf buds upon the lower branches. Morello cherries suffered a loss of 5 per ct. of the blossoms. Apples and pears were affected in the same degree. Crabs bore a full crop of fruit and foliage. Trees much infested with the scale, especially the plums, were usually severely injured or killed by the winter.

In Orchard III, which was infested with scale, there was no apparent reduction in the blossoms and leaves upon the moder-

*Reprint of Bulletin No. 254.

ately incrusted trees by any of the sprays, and subsequent growth and crop yields were in every respect equal to the checks. Trees much weakened by scale sustained the usual injuries consequent to a destructive winter.

The lime-sulphur wash, the lime-sulphur-salt wash and the lime-sulphur-caustic soda wash were equally effective as insecticides. Applications of these sprays controlled the scale, and with some slight exceptions insured the production of clean, marketable fruit.

INTRODUCTION.

With the complete infestation of large orchards, much trouble is usually experienced by fruit growers, especially when the sulphur washes are used, in spraying all of the trees satisfactorily during the dormant season in the spring. To facilitate treatment it has been frequently suggested in certain quarters that fall spraying be employed for a portion of the trees. While this has been seriously considered, orchardists have been deterred from this practice because little was known as to the results upon fruit trees and scale likely to attend such treatment.

As the exact effects of sulphur sprays applied at this season upon fruit and leaf buds and upon the scale had not been determined, the writer, in the fall of 1902, conducted a preliminary experiment with two of these washes for the treatment of peaches. In this work* it was shown that the applications of the lime-sulphur-salt wash and the lime-sulphur-copper sulphate wash were not detrimental to Elberta and Crosby peaches of Burbank and Lombard plums; and in the destruction of the scale compared favorably with early spring treatments. As it was desirable to ascertain if these results would hold good upon these and other varieties of fruit under different winter conditions before drawing any conclusions upon the use of these sulphur sprays for fall treatment the experiment was repeated in 1903 along essentially the same lines, but with some changes that were suggested by the previous year's experience.

In addition to this problem, a test was also made of several sulphur washes to ascertain their comparative insecticidal qualities. Since its introduction in the East a number of modifications of the lime-sulphur-salt wash have been proposed, which,

*Ohio Ag. Exp. Sta. Bul. 144; 37th Ann. Rept. Ohio State Hort. Soc., p. 57.

while promising, needed more extensive testing to determine their merits in comparison with recognized formulæ. The details of these experiments furnish the basis of this bulletin.

For their uniform courtesy and cordial coöperation, acknowledgments are due to Messrs. T. C. Maxwell & Bros., Mr. C. W. Ward, and Mr. Thos. Maney, who permitted the use of a portion of their orchards, and contributed in many ways to further the experiments.

OUTLINE OF THE EXPERIMENTS.

DESCRIPTION OF ORCHARDS.

The orchards in which the experiments were conducted are situated in Ontario county, near Geneva, and in Queens county, near Queens. Owing to the differences in their conditions and past treatment, which have an important bearing upon the results obtained, each orchard is described separately, as follows:

Orchard I (Messrs. T. C. Maxwell and Bros., Geneva).—In this orchard 25 Fitzgerald peaches and 70 Reine Claude plums were selected for treatment. The trees are about eight years old, and have received in every respect very careful attention. Both the varieties at the time of the application of the washes were thrifty and entirely free from scale.

Orchard II (Thos. Maney, Geneva).—For the purposes of the experiment 14 Baldwin and Hubbardston apples, 6 crabs, 33 Bartlett pears, 39 Morello cherries and 187 plums consisting principally of the varieties Abundance, Burbank, Field, Lombard and Reine Claude were used. These trees had not been previously treated for insects or fungi, but have in other respects been given good care. The apples are eighteen years and the remaining varieties six years old. The scale was discovered in the orchards in 1900 and was very abundant on many of the trees, especially the Burbanks and Reine Claudes which showed more or less injured twigs and branches as a result of the infestation.

Orchard III (C. W. Ward, Queens).—This orchard consists of 65 apples and 227 peach trees, principally of the varieties Elberta, Champion, Carman, Greensboro, Hiley and Thurber. The peaches vary from one to three years of age, and all except 91 were more or less infested with the scale. At the time of the treatment several of the adjoining trees had succumbed and a goodly number of those selected showed considerable dead wood as a result of injuries by this pest. The peach orchard has never been sprayed for insects or diseases. A small portion of the trees at the time of planting were first fumigated with hydrocyanic acid gas. The apple trees were variously infested with the scurfy bark louse and the San José scale.

The number of trees treated in this experiment was 666, consisting of 79 large apples, 33 pears, 257 plums, 39 cherries, 6 crabs and 252 peaches, which was sufficient to give definite results. In each orchard checks were reserved, which were as nearly representative as possible of the varieties, and of similar condition with respect to scale and past treatment as those under experiment.

CONDITIONS.

In the experiment at Queens the washes were applied during November 8 and November 13. The weather was clear with light south winds. The precipitation during the two weeks immediately following the last application was as follows: November 14, .075 inch; November 17, .805; November 23, .105; November 29, snow flurries.

At Geneva the applications of the washes were made during November 16 and November 27. The weather during this period was usually cloudy with light winds. The temperature varied in the mornings from 18° to 40°, and in the afternoons from 12° to 47° Fahr. Light snows fell daily between November 18 and 27. For the month following the last applications there was a gradual decline in the temperature, with light snows occurring on December 5, 6, 7, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 21, 22, 24, 25, 26 and 27.

The trees were sprayed once carefully and upon the following day a second treatment was made to cover the portions of the trees, which were not well coated by the first application. The time for the satisfactory spraying of the orchards was very limited owing to the retention of the foliage upon the trees till late in the fall and the early appearance of freezing weather which soon followed a cold wet season.

THE WASHES AND THEIR PREPARATION.

The washes used in this experiment were the lime-sulphur-salt wash, prepared with and without external heat; the lime-sulphur wash; and the lime-sulphur-caustic soda wash, prepared with and without external heat. Their formulæ and methods of preparation are as follows:

BOILED LIME-SULPHUR-SALT WASH.

(*Formula I.*)

Lime	15 pounds.
Sulphur	15 pounds.
Salt	15 pounds.
Water	50 gallons.

This was prepared in the usual method by first slaking the lime to a thin whitewash and then adding the sulphur and the salt. These ingredients were distributed thoroughly in the whitewash and the mixture boiled from one to two hours.

SELF-BOILED LIME-SULPHUR-SALT WASH.

(*Formula II.*)

Lime	40 pounds.
Sulphur	20 pounds.
Salt	15 pounds.
Water	60 gallons.

This wash was cooked without the direct use of external heat. First, the sulphur was made into a paste with hot water and was then emptied into a barrel containing 40 pounds of lime, which was started to slake with 12 gallons of boiling water. During the slaking process, the barrel was covered to prevent the loss of heat. Occasionally the wash was stirred to secure a more uniform distribution of the sulphur in the whitewash. In 20 minutes after the time that the lime first commenced to slake, enough boiling water was added to make the required 60 gallons of mixture; after which the salt was added and stirred until dissolved. The wash was then strained and applied hot.

LIME-SULPHUR WASH.

(*Formula III.*)

Lime	15 pounds.
Sulphur	15 pounds.
Water	50 gallons.

This mixture was made in the same manner as the boiled lime-sulphur-salt wash, except that the salt was omitted.

SELF-BOILED LIME-SULPHUR-CAUSTIC SODA WASH.

(*Formula IV.*)

Lime	30 pounds.
Sulphur	15 pounds.
Caustic soda	6 pounds.
Water	50 gallons.

In preparing this wash the lime was started to slake with six gallons of water; and, as soon as the slaking commenced the sulphur, which had just previously been made into a thin paste with hot water, was added and thoroughly mixed in with the slaking lime. To prolong the boiling of the wash, the caustic soda was then used, with water as needed, and the whole mixture was kept thoroughly stirred. As soon as the chemical action had ceased the required amount of water was added, when the mixture was ready for use. The soda used in the preparation of this wash is a powdered 74 per ct. caustic soda, sold by the Penn. Chemical Works, 1322 Washington Avenue, Philadelphia, Penn. It sells for four cents a pound and is contained in 50 pound cans.

BOILED LIME-SULPHUR-CAUSTIC SODA WASH.

(*Formula* V.)

Lime	30 pounds.
Sulphur	15 pounds.
Caustic soda	6 pounds.
Water	50 gallons.

This was prepared in the same manner as the self-boiled lime-sulphur-caustic soda, after which the mixture was boiled for one to two hours over a fire.

In each experiment with each variety of fruit the number of trees was divided as evenly as possible for treatment by the different sprays. Comparative tests were made of the above described washes in all of the orchards with the exception that in Messrs. T. C. Maxwell and Bros.' orchard the self-boiled lime-sulphur-salt wash was omitted and in Mr. C. W. Ward's orchard the self-boiled lime-sulphur-salt wash and the self-boiled lime-sulphur-caustic soda wash were omitted.

RESULTS.

ORCHARD I.

On peaches.—These trees were carefully examined during the early spring to note the effects of the treatments upon the buds. On May 1 there were evidences of injury upon the sprayed trees but the extent of the damage was difficult to estimate at this time. In comparison with the checks the buds of these trees were less advanced and fewer in number, while much of the wood of last year's growth was dead for from six to ten inches from the tips. On May 9, blossoms and leaves appeared upon the unsprayed, and on May 12 upon the sprayed trees.

To determine more minutely their conditions at this time a count was made of the number of blossoms and leaf buds upon four check trees and upon four trees from each of the different lots under treatment. The method followed in making this calculation was to ascertain the actual number of blossoms and leaf buds upon three representative branches of each tree. Upon these figures a computation was then made of the total number of blossoms and of leaf buds upon each tree. The results of this examination are given in the appended table which clearly shows the conditions of the trees under the various treatments:

TABLE I.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PEACH LEAF BUDS, BLOSSOM BUDS AND BLOSSOMS. (ORCHARD I.)

	TREE I: Branches.			TREE II: Branches.			TREE III: Branches.			TREE IV: Branches.		
	1	2	3	1	2	3	1	2	3	1	2	3
FORMULA I.												
Number of leaf buds to branch	25	20	30	40	56	9	46	24	15	35	40	20
Number of blossoms to branch	0	0	0	0	0	0	0	0	0	0	0	0
Computed number of leaf buds to tree	...	650	...	...	630	...	...	482	...	...	517	...
Computed number of blossoms to tree	...	0	...	...	0	...	...	0	...	...	0	...
Percentage of leaf buds killed	...	88.8	...	...	85.0	...	...	87.1	...	...	83.6	...
Percentage of blossoms killed	...	100	...	...	100	...	...	100	...	...	100	...
FORMULA III.												
Number of leaf buds to branch	103	118	71	29	86	220	90	10	130	67	23	125
Number of blossoms to branch	1	5	16	0	24	16	3	0	7	4	0	6
Computed number of leaf buds to tree	...	4,175	...	...	3,908	...	...	2,607	...	...	1,793	...
Computed number of blossoms to tree	...	315	...	...	467	...	...	113	...	...	83	...
Percentage of leaf buds killed	...	28.4	...	...	7.1	...	...	30.0	...	...	42.9	..
Percentage of blossoms killed	...	93.7	...	...	51.4	...	...	90.4	...	...	95.3	...
FORMULA IV.												
Number of leaf buds to branch	49	46	47	6	56	30	19	29	41	13	22	9
Number of blossoms to branch	0	0	0	0	0	0	0	0	0	0	0	2
Computed number of leaf buds to tree	...	710	...	...	429	...	...	326	...	...	249	...
Computed number of blossoms to tree	...	0	...	...	0	...	...	0	...	...	11	...
Percentage of leaf buds killed	...	87.8	...	...	89.8	...	...	91.2	...	...	92.1	...
Percentage of blossoms killed	...	100	...	...	100	...	...	100	...	...	99.4	...
FORMULA V.												
Number of leaf buds to branch	4	3	27	48	9	76	30	18	85	31	66	3
Number of blossoms to branch	1	0	0	5	0	3	5	0	6	0	2	0
Computed number of leaf buds to tree	...	1,587	...	...	1,419	...	...	1,330	...	...	967	...
Computed number of blossoms to tree	...	23	...	...	85	...	...	110	...	...	19	...
Percentage of leaf buds killed	...	72.8	...	...	66.3	...	...	64.3	...	...	69.2	...
Percentage of blossoms killed	...	99.5	...	...	91.2	...	...	90.6	...	...	98.9	...
CHECK.												
Number of leaf buds to branch	240	94	160	259	62	130	146	96	131	150	81	73
Number of blossoms to branch	147	132	138	36	28	39	44	40	9	108	35	26
Computed number of leaf buds to tree	...	5,828	...	...	4,209	...	...	3,725	...	...	3,141	...
Computed number of blossoms to tree	...	5,004	...	...	961	...	...	1,178	...	...	1,746	...

In comparison with the checks the average percentage of leaf buds killed upon the trees treated with the boiled lime-sulphur-salt wash is 86.1, of blossoms, 100.0; of leaf buds with the lime-sulphur wash, 27.1, of blossoms, 82.7; of leaf buds with the self-boiled lime-sulphur-caustic soda wash, 90.2, of blossoms, 99.8; leaf buds with the boiled lime-sulphur-caustic soda wash, 68.1, of blossoms, 95.0.

From May 12 the sprayed trees made a growth which compared favorable with that of the checks. Owing to the failure of the fruit to set, the crop was light. The condition of the trees on July 8 with respect to the production of fruits and leaves is shown by the following table:

TABLE II.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PEACH FRUITS AND LEAVES. (ORCHARD I.)

	TREE I:			TREE II:			TREE III:			TREE IV:		
	Branches.			Branches.			Branches.			Branches.		
	1	2	3	1	2	3	1	2	3	1	2	3
FORMULA I.												
Number of leaves to branch...	336	746	689	392	611	679	576	659	543	485	664	337
Number of fruits to branch....	0	0	0	0	0	0	0	0	0	0	0	0
Computed number of leaves to tree....................	...	23,613	...	...	22,987	...	...	22,521	...	...	17,337	...
Computed number of fruits to tree....................	...	0	...	...	0	...	...	0	...	...	0	...
Average percentage loss of leaves	...	38.5	...	...	44.8	...	...	+3.1	...	...	41.1	...
Average percentage loss of fruits.	...	100	...	...	100	...	...	100	...	...	100	...
FORMULA III												
Number of leaves to branch...	751	832	495	817	674	543	407	796	167	453	871	697
Number of fruits to branch....	0	1	0	3	0	0	0	1	0	0	1	0
Computed number of leaves to tree....................	...	35,326	...	...	30,585	...	...	20,093	...	...	28,294	...
Computed number of fruits to tree....................	...	17	...	...	45	...	...	15	...	...	14	...
Average percentage loss of leaves	...	8.0	...	...	26.6	...	...	8.0	...	...	3.8	...
Average percentage loss of fruits.	...	95.6	...	...	61.9	...	...	90.3	...	...	93.6	...
FORMULA IV.												
Number of leaves to branch...	...	......	...	...	......	...	465	645	597	386	594	185
Number of fruits to branch....	...	......	...	...	......	...	0	0	0	0	0	0
Computed number of leaves to tree....................	...	......	...	...	......	...	...	26,174	...	...	13,592	...
Computed number of fruits to tree....................	...	......	...	...	......	...	...	0	...	...	0	...
Average percentage loss of leaves	...	......	...	...	......	...	...	+19.8	...	...	53.8	...
Average percentage loss of fruits.	...	......	...	...	......	...	...	100	...	...	100	...
FORMULA V.												
Number of leaves to branch...	396	3	47	444	494	376	297	465	134	307	559	217
Number of fruits to branch....	0	0	0	0	0	0	0	0	0	0	0	0
Computed number of leaves to tree....................	...	5,649	...	...	17,958	...	...	13,141	...	...	16,245	...
Computed number of fruits to tree....................	...	0	...	...	0	...	...	0	...	...	0	...
Average percentage loss of leaves	...	85.3	...	...	56.9	...	...	39.8	...	...	44.8	...
Average percentage loss of fruits.	...	100	...	...	100	...	...	100	...	...	100	...
CHECK.												
Number of leaves to branch...	931	793	675	697	598	824	434	505	621	541	618	846
Number of fruits to branch....	0	22	2	2	4	0	7	1	3	1	9	5
Computed number of leaves to tree....................	...	38,384	...	...	41,674	...	...	21,840	...	...	29,407	...
Computed number of fruits to tree....................	...	384	...	...	118	...	...	154	...	...	220	...

Compared with the checks there were no fruits and 69.7 per cent. of a crop of fruit upon the trees treated with the boiled lime-sulphur-salt wash; 14.6 per cent. of a crop of fruit and 88.4 per cent. of a crop of leaves upon trees treated with the lime-sulphur wash; no fruits and 83.3 per cent. of a crop of leaves upon trees treated with the self-boiled lime-sulphur-caustic soda wash; no fruits and 43.3 per cent. of a crop of leaves upon trees treated with the boiled lime-sulphur-caustic soda wash.

Beginning with July 10, there was a very apparent decline in the condition of many of the checks. The little growth that had been made upon such trees was commencing to drop its leaves. The remaining trees were making a good growth and from external appearances were as thrifty as the sprayed lots. On August 1, twenty of the checks were dead, and thirty-two were shedding their fruits and leaves. Likewise two of the trees treated with the self-boiled lime-sulphur-caustic soda wash had succumbed, and one tree in each of the lots sprayed with the boiled lime-sulphur-salt wash and the boiled lime-sulphur-caustic soda wash respectively had considerable dead wood. The condition of the remaining sprayed trees appeared to be entirely satisfactory, with the exception of the fruit. The new growth and the amount of the foliage was fully equal to if not better than that of the average check.

The results obtained in this orchard show that there was more or less injury done by the winter, although the external appearance of the trees did not show such during the spring or the early summer. In case of the treated trees the effects of the sprays were apparently to aggravate the evil consequences of a destructive winter, while the loss of a goodly portion of the fruit blossoms by the applications served in turn to promote the recuperation of the trees. The behavior of the checks would indicate that their attempt to mature a crop of fruit was, for them in their weakened state, a severe tax, and, in many instances, a fatal drain upon their depleted vitality.

On plums.—Observations upon these trees during the latter part of April showed that there were differences in their condition which varied according to the spray applied. The buds of the treated trees were delayed in opening about the same length of time as the peaches. At their appearance it was clearly apparent that the blossoms and the leaves upon the sprayed trees were uniformly less numerous than upon the checks, and that there was a rather definite relation between their numbers and the spraying mixture employed. The conditions of the trees at this date, May 12, are shown by the appended table which was constructed in the same manner as the preceding ones upon the peaches:

TABLE III.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PLUM LEAF BUDS, BLOSSOM BUDS AND BLOSSOMS. (ORCHARD I.)

	TREE I:			TREE II:			TREE III:		
	Branches.			Branches.			Branches.		
	1	2	3	1	2	3	1	2	3
FORMULA I.									
Number of leaf buds to branch	43	62	10	44	60	84	57	74	45
Number of blossoms to branch	1	6	3	13	25	11	9	5	11
Computed number of leaf buds to tree	...	230	...	...	627	...	...	821	...
Computed number of blossoms to tree	...	20	...	...	163	...	...	117	...
Percentage of leaf buds lost	...	86.6	...	...	65.1	...	...	+11.8	...
Percentage of blossoms killed	...	98.8	...	...	92.0	...	...	83.6	...
FORMULA III.									
Number of leaf buds to branch	57	70	43	81	135	70	91	92	76
Number of blossoms to branch	51	13	16	25	11	45	94	132	66
Computed number of leaf buds to tree	...	344	...	...	858	...	...	950	...
Computed number of blossoms to tree	...	160	...	...	243	...	...	1,071	...
Percentage of leaf buds lost	...	79.8	...	...	52.2	...	...	+32.8	...
Percentage of blossoms killed	...	90.8	...	...	88.1	...	...	5.6	...
FORMULA IV.									
Number of leaf buds to branch	27	6	29	20	24	19	21	27	16
Number of blossoms to branch	2	2	5	7	5	0	0	0	2
Computed number of leaf buds to tree	...	102	...	...	252	...	...	235	...
Computed number of blossoms to tree	...	15	...	...	48	...	...	7	...
Percentage of leaf buds lost	...	94.0	...	...	86.0	...	...	67.1	...
Percentage of blossoms killed	...	99.1	...	...	97.7	...	...	99.4	...
FORMULA V.									
Number of leaf buds to branch	46	63	53	32	41	42	26	52	29
Number of blossoms to branch	69	89	28	12	6	12	21	16	11
Computed number of leaf buds to tree	...	540	...	...	268	...	...	321	...
Computed number of blossoms to tree	...	620	...	...	70	...	...	144	...
Percentage of leaf buds lost	...	68.5	...	...	85.1	...	...	55.1	...
Percentage of blossoms killed	...	64.3	...	...	96.6	...	...	87.3	...
CHECK.									
Number of leaf buds to branch	90	98	114	97	125	95	59	49	59
Number of blossoms to branch	102	97	107	92	154	114	79	92	91
Computed number of leaf buds to tree	...	1,711	...	...	1,796	...	...	715	...
Computed number of blossoms to tree	...	1,734	...	...	2,040	...	...	1,135	...

In comparison with the checks there was an average loss of 91.4 per ct. of the blossoms and 46.6 per ct. of the leaves upon the trees treated by the boiled lime-sulphur-salt wash; 61.5 per ct. of the blossoms and 33.1 per ct. of the leaves upon the trees treated by the lime-sulphur wash; 98.7 per ct. of the blossoms and 82.3 per ct. of the leaves upon the trees treated by the self-boiled lime-sulphur-caustic soda wash; and 82.7 per ct. of the blossoms, and 69.5 per ct. of the leaves upon the trees treated by the boiled lime-sulphur-caustic soda wash.

With the falling of the blossoms there was a marked improvement in the conditions of the treated trees. The amount of fruit set was small upon both the sprayed and unsprayed lots. The relative abundance of fruits and leaves upon the trees on July 8 under the various treatments is shown by the accompanying table:

TABLE IV.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PLUM LEAVES AND FRUIT. (ORCHARD I.)

	TREE I:			TREE II:			TREE III:			TREE IV:		
	Branches.			Branches.			Branches.			Branches.		
	1	2	3	1	2	3	1	2	3	1	2	3
FORMULA I.												
Number of leaves to branch	352	204	132	110	487	452	232	254	323	233	202	186
Number of fruits to branch	0	0	0	0	0	0	0	0	0	1	0	0
Computed number of leaves to tree	...	1,376	...	...	3,463	...	...	3,775	...	...	1,656	...
Computed number of fruits to tree	...	0	...	...	0	...	...	0	...	...	3	...
Average percentage loss of leaves	...	77.5	...	...	47.8	...	...	19.4	...	...	73.8	...
Average percentage loss of fruits	...	100	...	...	100	...	...	100	...	...	100	...
FORMULA III.												
Number of leaves to branch	283	129	391	396	272	481	131	251	212	274	328	249
Number of fruits to branch	0	0	0	0	0	0	5	0	1	0	0	0
Computed number of leaves to tree	...	1,606	...	...	3,447	...	...	2,178	...	...	3,971	...
Computed number of fruits to tree	...	0	...	...	0	...	...	242	...	...	0	...
Average percentage loss of leaves	...	73.7	...	...	48.1	...	...	53.5	...	...	37.3	...
Average percentage loss of fruits	...	100	...	...	100	...	...	+90.9	...	...	100	...
FORMULA IV.												
Number of leaves to branch	145	106	161	227	147	211	207	133	159	224	173	276
Number of fruits to branch	0	0	0	0	0	0	0	0	0	0	0	0
Computed number of leaves to tree	...	8.24	...	...	2,730	...	...	2,495	...	...	3,589	...
Computed number of fruits to tree	...	0	...	...	0	...	...	0	...	...	0	...
Average percentage loss of leaves	...	86.5	...	...	58.9	...	...	46.7	...	...	43.3	...
Average percentage loss of fruits	...	100	...	...	100	...	...	100	...	...	100	...
FORMULA V.												
Number of leaves to branch	330	249	183	241	163	192	296	209	173	253	212	248
Number of fruits to branch	0	1	0	0	0	0	0	0	0	0	0	0
Computed number of leaves to tree	...	2,540	...	...	1,788	...	...	2,260	...	...	2,852	...
Computed number of fruits to tree	...	3	...	...	0	...	...	0	...	...	0	...
Average percentage loss of leaves	...	58.4	...	...	73.1	...	...	51.7	...	...	54.9	...
Average percentage loss of fruits	...	95.2	...	...	100	...	...	100	...	...	100	...
CHECK.												
Number of leaves to branch	426	263	388	456	293	422	304	415	362	308	439	371
Number of fruits to branch	4	3	4	0	1	1	1	4	0	1	1	1
Computed number of leaves to tree	...	6,103	...	...	6,636	...	...	4,684	...	...	6,335	...
Computed number of fruits to tree	...	62	...	...	11	...	...	22	...	...	17	...

Comparing the sprayed with the unsprayed trees it will be seen that there were no fruits and 45.4 per ct. of a crop of leaves upon trees treated with the boiled lime-sulphur-salt wash; 47.8 per ct. of a crop of fruit and 46.9 per ct. of a crop of leaves upon trees treated with the lime-sulphur wash; no fruits and 41.2 per ct. of a crop of leaves upon trees treated with the self-boiled lime-sulphur-caustic soda wash; and 1.2 per ct. of a crop of fruit and 40.5 per ct. of a crop of leaves upon the trees treated with the boiled lime-sulphur-caustic soda wash.

On August 2, there was very little difference in the appearance of the trees in the different lots. In comparison with the checks the sprayed trees as a rule had fewer leaves upon the lower branches, but on account of the superior new growth of the latter the amount of foliage was approximately the same for both. The relative proportions in the fruit yields did not show any apparent variations from former observations.

ORCHARD II.

On trees.—On May 5, there were marked differences in the appearances of the trees owing to the effects of the winter upon those that were much infested with the scale. Such trees were usually dead or had a scanty crop of blossoms and leaves and much dead wood. Trees free from scale or only slightly infested were as a rule entirely healthy and had a large percentage of live fruit and leaf buds. On May 12, nearly all of the trees were in full blossom. An examination of the plums, slightly or not at all infested with the scale, principally of the varieties Reine Claude, Abundance, Field and Red June to determine the conditions of the trees gave the following figures:

TABLE V.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON REINE CLAUDE, ABUNDANCE, FIELD AND RED JUNE PLUMS. (ORCHARD II.)

TREATMENT.	No. of trees.	Conditions of sprayed trees compared with checks.
FORMULA I. Boiled lime-sulphur-salt wash.	38	Trees have 75 to 80 per ct. of a crop of blossoms and foliage equal to checks. Injuries more apparent on lowest branches.
FORMULA II. Self-boiled lime-sulphur-salt wash.	36	Trees have 75 to 80 per ct. of a crop of blossoms and foliage equal to checks. Injuries more apparent on lowest branches.
FORMULA III. Lime-sulphur wash.	28	Trees have from 80 to 90 per ct. of a crop of blossoms and foliage equal to checks. Losses principally upon lowest branches.
FORMULA IV. Self-boiled lime-sulphur-caustic soda wash.	72	Trees have from 50 to 65 per ct. of a crop of blossoms and foliage equal to checks. Injuries more apparent upon lowest branches.
FORMULA V. Boiled lime-sulphur-caustic soda wash.	64	Trees have from 65 to 80 per ct. of a crop of blossoms and foliage equal to checks.

Owing to the failure of the fruit to set the quantity upon the trees was very small and did not exceed on August 12 from two to forty per ct. of a crop according to the variety on either the checks or treated rows. The new growth and the amount of foliage of the sprayed trees was equal to that of the checks. The only apparent difference in the treated and untreated trees was that upon the lower branches of some of the former the number of the leaves was somewhat smaller.

The results upon the Burbanks were about the same as with the above varieties. The conditions of thirty-six trees treated with the self-boiled lime-sulphur-caustic soda wash compared with that of uninfested checks appeared as follows: Trees not infested with scale had 85 per ct. of a crop of blossoms, and a full amount of foliage; moderately infested trees had about 70 per ct. of a crop of blossoms and a full crop of leaves; while the badly infested trees had from 0 to 35 per ct. of a crop of blossoms and about 65 per ct. of a crop of leaves. Trees of this variety that were much improved by the winter showed later a remarkable improvement in their conditions on account of the destruction of the scale.

Morello cherries lost about five per ct. of the blossoms and a small number of leaf buds upon the lower branches. Apples and pears were affected in about the same degree. Crab apples bore a full crop of fruit and foliage.

Effects on scale with boiled lime-sulphur-salt wash.—On August 12, an examination was made of the fall treated trees to note their conditions in comparison with those of the checks and other trees which had received similar treatment in the spring only. There was no apparent difference in the results upon the scale by the fall and spring applications. Several pear and plum fruits exhibited slight markings by the scale, and at the base of the new growth of some of the trees there were small colonies of living scales. The incrustation which was composed of the old scales was lifeless and much weather-worn.

With self-boiled lime-sulphur salt wash.—The results upon the scale by this formula were essentially the same as with the preceding wash. While proving satisfactory in the present experiment this wash showed considerable variation in its effects upon this insect when used for spring treatment, indicating that the various preparations were not always uniform in their composition.

With lime-sulphur wash.—This formula was uniformly effective and gave results which were similar to those attending the use of boiled lime-sulphur-salt wash.

With lime-sulphur-caustic soda washes.—The applications of these sprays efficiently controlled the scale, giving results which were practically the same as those obtained by the boiled lime-sulphur salt wash. The destruction of the scale upon the apples, pears and plums with smooth bark seemed complete, but upon the Burbanks there was a small percentage of the fruits that was infested.

ORCHARD III.

Results on trees.—An examination of this orchard on May 13 showed that there was no apparent difference in the appearance of the sprayed and unsprayed peach trees, that previous to treatment were free from or only slightly infested with scale. The blossoms and leaves were normal. Trees weakened by the scale were usually much injured or killed by the winter. At this date there were traces of leaf curl upon such varieties as Carman, Champion, Elberta, Hiley, Greensboro, and Mountain Rose. On May 30, Mr. Sirrine made a careful examination of the conditions of the trees with respect to the leaf curl and estimated that nearly 55 per ct. of the foliage upon the unsprayed and one per ct. of that of the sprayed trees were affected by this disease. By July 23 these differences had disappeared, and crop yields and foliage were apparently the same for the sprayed and unsprayed trees. The apple leaf buds and fruit buds were unaffected by the sprays. With the advance of the summer there was a marked increase in the vigor and healthfulness of the sprayed apple trees in comparison with that of the checks.

Results on scurfy bark louse.—This species was almost entirely destroyed upon the trees sprayed with a sulphur wash.

Results on San José scale.—The lime-sulphur-salt wash, the lime-sulphur wash, and the lime-sulphur-caustic soda wash were equally effective. The applications upon the peach trees almost entirely controlled the scale. Upon a few trees in all of the different lots small numbers of larvæ were found, which was probably due to lack of thoroughness in treatment. Comparing the fall-treated with spring-treated trees it is believed that the treatment of the latter was slightly more effective. Upon the upper parts of the tallest apple trees which were difficult to reach by the sprays quite a number of the fruits were spotted with the scale, but on the lower portions where spraying had been thorough the bark and fruit were uniformly clean.

GENERAL SUMMARY AND DISCUSSION OF RESULTS.

The results obtained in the different orchards by the fall applications of the sulphur washes show considerable variation in the effects of the treatments upon leaf and fruit buds. In Orchard I the spraying was accompanied by a reduction in the amount of the bloom and foliage. There was an average loss of 71.8 per ct. of the blossoms and 67.8 per ct. of the leaves upon the peaches, and 83.5 per ct. of the blossoms and 57.8 per ct. of the leaves upon the plums sprayed with these washes. The least destructiveness was shown by the lime-sulphur wash which caused a loss of 82.7 per ct. of the blossoms and 27.1 per ct. of the leaves upon the peaches; and 61.5 per ct. of the blossoms and 33.1 per ct. of the leaves upon the plums. With the dropping of the blossoms there was a marked improvement in the conditions of the sprayed trees, which, with the exception of the smaller yield of fruit, ultimately equalled the checks in appearance. In Orchard II plum blossoms were reduced by 10 to 50 per ct. with slight injuries to foliage. The Morello cherries lost 5 per ct. of their blossoms. Apples and pears were similarly affected, and crabs sustained no apparent injuries. Trees much infested with scale were either killed or severely injured by the winter. In Orchard III the sprayed trees with the exception of those sustaining injuries by the scale and the winter were unaffected by the treatments. The sprayed apples showed later in the season increased vigor and healthfulness as a result of the control of the scale.

Owing to the variation in the results by the sprays upon fruit trees which is partly attributable to the severe winter the experiment has given conflicting data. For this reason a further study of the question under varied conditions is necessary before the exact effects of fall spraying upon crop yields in average years can be determined. The work accomplished shows that sulphur washes applied in the fall may under certain conditions cause injuries such as sometimes attend the excessive use of these sprays in the spring. But it is believed to be advisable, when experience has shown that it is impossible to spray all of the trees in the spring, that fall spraying be employed for the treatment for the hardier varieties of fruits—as the increased vigor and usefulness of the trees arising from the control of the scale will more than compensate for probable losses in fruit yields.

All of the washes tested proved equally effective in the destruction of the scale. The addition of caustic soda or salt to a lime-sulphur wash cooked by fire or steam did not add to its effectiveness. While satisfactory in the present experiment later tests with the lime-sulphur-salt wash prepared without external heat showed that there may be considerable variation in the various preparations which may be largely avoided by using high grade lime and knack in the cooking operations. The washes that are well suited to the needs of average orchardists are the lime-sulphur wash boiled by fire or steam and the lime-sulphur-caustic soda wash, prepared without external heat.

THE PEAR PSYLLA.*

P. J. PARROTT.

The extensive winter-killing of pear trees as a result of the attacks of the pear psylla last summer has attracted considerable attention to this pest. To meet the demand for information, this brief account of this destructive insect has been prepared to direct orchardists in the methods by which better protection may be given their pear trees.

SYMPTOMS OF PSYLLA ATTACK.

The presence of the psylla in injurious numbers upon a tree is usually indicated by an abundance of a waterish, sticky liquid, called honey dew, which may be first detected during the latter part of May or early in June at the axils of the leaves and fruits. This liquid later becomes covered with a black mold, which gives the trees a blackish, unsightly appearance. Certain ants and flies are very fond of the honey dew, and are often attracted by it in numbers to infested trees. The presence of these insects upon a pear tree should arose the suspicions of a careful observing orchardist and should lead to a close inspection of the trees if attack by the psylla has not been apprehended.

APPEARANCE AND HABITS OF THE PSYLLA.

The adult is an active four-winged insect, measuring about one-tenth of an inch in length. It has been compared to a miniature seventeen year locust. A number of broods are produced during the summer and the adults which live through the winter are quite distinct from the summer adults. They appear early in the spring and deposit their eggs in protected places in the bark. The eggs hatch in a few days and the little larvæ or nymphs at once commence to suck the juices from the young leaves and twigs. A favorite place for the young nymphs is in

*Reprint of Circular No. 5, New Series.

the axils of the leaves and at the base of the fruit stems. Within two or three days after hatching they cover themselves with honey dew which finally becomes so abundant as to disfigure leaves and fruits. The amount of injury done in this way varies of course with the number of the nymphs. When the nymphs are very numerous they take so much nourishment from the trees that the new growth is seriously checked. The whole tree assumes a stunted, unhealthy appearance. As a result the fruit crop is greatly lessened and in some cases trees have been killed. Many trees weakened by the psylla last summer failed to survive the winter.

TREATMENT.

The young nymphs are the most easily reached. Close watch for them should be kept when the leaves are unfolding in the spring. As soon as the nymphs are found spray the trees thoroughly with kerosene emulsion, diluted with about ten parts of water or with a solution of whale oil soap, one pound to four to six gallons of water. The secret of success in fighting this insect is early and thorough spraying. It may be necessary to make two or three applications at intervals of three or four days to successfully control the pest. The orchardist should watch the results of the treatments to determine if the strength of the spray is satisfactory. Spraying should not be long delayed after the appearance of the nymphs, for it is much more difficult to kill them when once they are protected by the honey dew.

PREPARATION OF SPRAYS.

Kerosene emulsion.—Dissolve ½lb. finely divided common soap or whale oil soap in one gallon of water, preferably rain water, and while it is still boiling, remove it from the fire and add two gallons of kerosene. Then agitate the mixture violently by forcing it through a spray pump, back into the vessel again until it becomes a creamy mass that will not separate. For use, dilute as directed.

Whale oil soap.—Whale oil soap may be purchased from the following manufacturers:—The Bowker Chemical Co., Boston, Mass.; James Good, Nos. 939 and 941 North Front Street, Philadelphia, Penn.; Poole & Bailey, No. 357 Canal Street, New York city; W. H. Owen, Catawba Is., Ohio.

Soaps often show considerable variation in their composition. For this reason the orchardist should watch the results of the applications and determine what amount may be safely employed for the destruction of the psylla. One pound of hard soap, such as Leggett's Anchor Brand, is commonly used to four gallons of water.

Sulphur washes.—These are promising remedies for this pest, and are especially recommended for the treatment during dormant season of trees infested with both the scale and pear psylla. The experimental orchards treated this spring were remarkably exempt from the first brood of the psylla, while the checks (untreated trees) were much infested. These sprays kill many of the adults and are apparently destructive to the newly hatched nymphs. Directions for preparing these washes may be obtained upon application to the Station, Geneva, N. Y.

REPORT

OF THE

Horticultural Department.

S. A. Beach, *Horticulturist.*

*V. A. Clark, *Assistant.*

†N. O. Booth, *Assistant.*

O. M. Taylor, *Foreman.*

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*Resigned Sept. 15, 1904.

†Appointed Oct. 10, 1904.

REPORT OF THE HORTICULTURAL DEPARTMENT.

AN EXPERIMENT IN SHADING STRAWBERRIES.*

O. M. Taylor and V. A. Clark.

SUMMARY.

An experiment in shading strawberries has been carried on by this Station for two seasons and in three localities. As managed in our experiments the practice has not proved profitable in growing fruit for the general market. Only when a thin cheese-cloth was used was any increase in yield obtained, while with a moderately heavy cheese-cloth there was a marked decrease. In no case was the increase in yield sufficient to pay for the added cost of shading, which is estimated to be about $350 per acre.

Shading produces a considerably larger berry and in some cases one of better general appearance. For these reasons the practice may be adapted for the growing of fancy and exhibition fruit.

Shading introduces something like hot-house conditions. Aside from its value as a protection against frost, its beneficial effects are due in large part to the protection it affords from wind. Evaporation and transpiration are much reduced, resulting in great economy of soil moisture. The temperature of air and of soil is raised somewhat, resulting theoretically in more rapid growth and increased earliness, provided these results are not offset by too great diminution of light; but these results have not been obtained in these experiments, though they have by other workers. Interference with the access of light is the weak point in shading. The cover must be of such material as to transmit the largest possible part of the light. It is noteworthy that the varieties that have given best results under cover in our tests,

*Reprint of Bulletin No. 246.

Marshall and Brandywine, are two of the varieties known by experience to be among those best adapted for growing under glass.

INTRODUCTION.

The shading of strawberries is a horticultural practice not generally introduced or known in commercial strawberry culture. However some notable results have recently been reported as obtained through the application of the method.*

The object of the experiments reported herein was to study the method critically with a view to estimating its value in practice.

OUTLINE OF THE EXPERIMENTS.

GENERAL NOTES.

The experiment was begun by the senior author of this bulletin in the spring of 1902, at Shortsville, N. Y., in coöperation with Mr. J. Q. Wells, and at Penn Yan with Mr. E. C. Gillett. The Station thanks both of these gentlemen for courtesies extended and assistance rendered. In 1903 the experiment at Penn Yan was continued and a duplicate experiment inaugurated on the Station grounds at Geneva. The experiment at Shortsville was discontinued.

The season of 1902 was exceptionally unfavorable for bringing out the merits of the practice on account of the excessive rains that prevailed; but the extraordinary period of drought in the spring of 1903 subjected the method to a severe test.

THE PLANTS AND THEIR PROTECTION.

Preparations were made for the experiment at Geneva in the spring of 1902. Two rows each of Marshall, Brandywine and Ridgeway, and one row each of Wm. Belt, Hunn and Gandy were set by the matted row system. The rows were 70 feet long, and 3½ feet apart, with the plants 2 feet apart in the row. These were to be shaded. A duplicate plat adjoining was set for the check. The row of Gandy in the check was near the cloth cover and was much affected by it; consequently the results with this variety are not considered. The plants were uniformly given good culture according to the practice of good strawberry growers.

*Blacknall, O. W. Growing strawberries under cover. *The Strawberry Specialist*, Feb., 1902.

The material used for the cover was thin cheese-cloth known as "Bombay," which cost about 4 cents per yard. The strips were sewed together into one piece large enough to cover the ground for about two feet around the outside of the bed. A strong cord was hemmed in the margin on the four sides and to this small rings were sewed at intervals of three feet.

The stakes used to support the cover were placed three feet apart around the outside of the plat. To the tops of these stakes were stapled small snaps to which the rings already referred to were fastened. To support the canvas, stakes were driven 10 feet apart in every other row. The tops were padded to prevent wearing holes in the cloth. Over the tops of these stakes wires were strung lengthwise of the rows for the canvas to rest on. All stakes except those to which the supporting wires were attached were two and one-half feet long and were driven down about 10 inches thus supporting the canvas about 20 inches above the ground. See Plates XII and XIII. The experimental plat at Penn Yan (see Plate XII, fig. 2) was laid out in a bearing field, had an area of 39x50 feet and included 15 rows. A continuation of the same rows formed the check, but with an interval of two feet between the plats to avoid influence of the cover on the check. The cloth in the cover was one commercial grade heavier than that used at Geneva. The variety grown was Sample, with a considerable intermixture of other varieties for purposes of cross pollination.

COST OF SHADING.

A detailed account of the cost of this experiment was not kept. But the cost of the cloth was about $11.00; the charge for sewing, including charge for rings sewed into the hem, $4.00; and the cost of the snaps used was $1.00. The Station already had the stakes and wire that were used. We estimate that the first cost of covering an acre in this way would be about $350.

It probably would not be advisable to use single pieces of cloth more than one-tenth acre in area because the cloth is very heavy and inconvenient to move and because the larger the piece the more easily is it torn by high winds. At the Station it was necessary to mend rents in the material several times after high winds and at the end of the second season the cover was so much torn that it had to be thrown away.

EFFECT OF THE COVER ON THE ENVIRONMENT OF THE PLANT.

The cover affects the growth of plants by modifying their physical environment in certain respects, the principal changes being in temperature and moisture content of air and of soil, velocity of wind and intensity of light. These changes in environment bring about changes in the physiological activities of the plant and these in turn are the cause of the peculiar behavior and the gross results observed in practice.

At the Station in 1903 records were made at 7 a. m., and 12 m. and 6 p. m., of the temperature of the air in the shade at the surface of the soil in both shaded plat and check. The thermometers were supported about two inches above the ground in a grape basket set on end, fastened to a stake and opening to the north. Other thermometers were set in the ground nearby to a depth of 3½ inches to measure soil temperatures. The records of all these observations are shown, with other data, in Tables I and II, pages 233, 235.

EFFECT OF THE COVER ON THE TEMPERATURE OF THE AIR.

The effect of the cover on the temperature of the air underneath was to raise it somewhat except on very cloudy days, when there was no effect. During the period of observation, from May 1 to June 30, there was only one day, May 20, when it did not appear to be at least a little warmer under the cover than outside. This was a cold, cloudy day following a night temperature close to freezing.

TABLE I.—RECORD OF TEMPERATURE OF AIR, CLOUDINESS AND EVAPORATION.

DATE.	Shaded.			Unshaded.			Degrees Warmer When Shaded.			Avg. per day.	Cloudiness.			Evaporation.	
	A. M.	M.	P. M.	A. M.	M.	P. M.	A. M.	M.	P. M.		A. M.	M.	P. M.	Shaded.	Unshaded.
	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.	Deg. F.				32nds of an in.	
May 1.....	....	46	45	....	46	41.5	.....	5.5	3.5	3	....	Clear	Clear		
2.....	42.5	68.5	60	40	59.5	59	2.5	9	1	4.2	Clear	Clear	Clear		
3.....	46	69.5	63	45	65	52	1	4.5	11	5.2	Cloudy	Clear	Cloudy		
4.....	44	57	55	44	55	54	0	2	1	1	Cloudy	Cloudy	Clear		
5.....	40	80	63.5	41	70	61	−1	10	2.5	3.8	Clear	Clear	Clear		
6.....	47	80.5	74.5	46.5	77.5	73	0.5	3	1.5	1.7	Clear	Semi-clear	Clear		
7.....	52	65	51.5	51	60.5	50.5	1	5.5	1	2.5	Cloudy	Cloudy	Cloudy		
8.....	51	79	70	51	73	68.5	0	6	1.5	2.5	Clear	Clear	Clear		
9.....	52	91.5	83	52.5	83	81	−0.5	8.5	2	3.3	Clear	Clear	Clear		
10.....	61	99	90	63.5	85.5	77.5	−2.5	13.5	2.5	4.5	Clear	Clear	Semi-clear		
11.....	58	91.5	81	58.5	82.5	78.5	−0.5	9	2.5	3.7	Clear	Clear	Clear.		
12.....	55	93	83	56.5	83	80	−1.5	10	3	3.8	Clare	Clear	Semi-clear	4	9
13.....	58	95	85.5	59.5	85	83	−1.5	10	2.5	3.7	Clear	Clear	Semi-clear	4	9
14.....	56.5	78.5	62	56.5	72	60	0	6.5	2	2.8	Semi-clear	Semi-clear	Semi-clear	2	4
15.....	52.5	80	73	52.5	75	71	0	5	2	2.3	Cloudy	Cloudy	Clear	4	9
16.....	56	95.5	83	58	85	83	−2	10.5	2	3.5	Clear	Semi-clear	Semi-clear	3	8
17.....	67	95	85	66	88	82	1	7	3	3.7	Clear	Semi-clear	Clear	4	8
18.....	64.5	92.5	85	65	87	84.5	−0.5	5.5	0.5	1.8	Clear	Semi-clear	Clear	3	7
19.....	66	100	84.5	67	94	85	−1	6	−0.5	1.8	Clear	Clear	Clear	5	8
20.....	72.5	90.5	80.5	76.5	87	79	−4	3.5	0.5	0	Cloudy	Cloudy	Semi-clear	6	10
21.....	65	99	85.5	66	91	85	−1	8	0.5	2.5	Clear	Clear	Clear	7	12
22.....	69	83	75.5	69.5	74	70.5	−0.5	9	5	4.5	Clear	Clear	Clear	5	9
23.....	58	77	64	56	66	61	2	11	3	5.3	Clear	Clear	Clear	4	9
24.....	52	63.5	71	50	60	69	2	3.5	2	2.5	Cloudy	Cloudy	Cloudy	3	5
25.....	53	89	79	55	76.5	75.5	−2	12.5	3 5	4.7	Clear	Clear	Clear	6	9
26.....	57.5	66	68	59	65	66	−1.5	1	2	0.5	Semi-clear	Cloudy	Semi-clear		*
27.....	60.5	83	76.5	61	80	75	−0.5	3	1.5	1.3	Cloudy	Semi-clear	Cloudy		*
28.....	67	81	75.5	67	79.5	76	0	1.5	−0.5	0.7	Semi-clear	Clear	Clear		*
29.....	52	69	67	49	65	64.5	3	4	2.5	3.2	Cloudy	Cloudy	Cloudy		*
30.....	50	74.5	64	50	62	58	0	12.5	6	6.2	Clear	Clear	Clear		*
31.....	50	77	67	49	67.5	63	1	9.5	4	4.8	Clear	Clear	Clear		*
June 1.....	56.5	90	72	58	80	70	−1.5	10	2	3.5	Clear	Clear	Cloudy	4	10
2.....	60	90	76.5	62	81.5	73	−2	8.5	3.5	3.3	Clear	Clear	Clear	5	8
3.....	61.5	93	83	66	86	82.5	−4.5	7	0.5	1	Clear	Clear	Clear	7	13
4.....	58.5	84	76	58.5	77.5	73	0	6.5	3	3.2	Semi-clear	Semi-clear	Semi-clear	4	8
5.....	53	84.5	67.5	53	80.5	67.5	0	4	0	1.3	Semi-clear	Semi-clear	Semi-clear	3	9
6.....	62	86	87	61.5	81	84	0.5	5	3	2.8	Semi-clear	Semi-clear	Semi-clear		
7.....	65	81	68	63.5	79.5	68	1.5	1.5	0	1	Semi-clear	Cloudy	Cloudy		
8.....	71	72	68.5	69.5	71	68.5	1.5	1	0	0.8	Cloudy	Cloudy	Cloudy		
9.....	67	96	73	66.5	88	73	0.5	8	0	2.8	Semi-clear	Clear	Cloudy		
10.....	70	68	64	68	66	63.5	2	2	0.5	1.5	Cloudy	Cloudy	Cloudy		
11.....	59.5	75	60	59	71	59	0.5	4	1	1.8	Semi-clear	Clear	Cloudy		
12.....	*	....	....	....	....	....	.....	.....	.....	.....	....	....	....		
13.....	55	68	68	54	65	65	1	3	3	2.3	Cloudy	Cloudy	Cloudy		
14.....	53	56	....	51	54	....	2	2	.....	.....	Cloudy	Cloudy	....		
15.....	54.5	70	71	54	66	71	0.5	4	0	1.5	Cloudy	Clear	Clear		
16.....	62	82	76	64	77	73	−2	5	3	2	Clear	Clear	Clear		
17.....	61	60	61.5	60.5	58	62	0 5	2	−0.5	0.7	Cloudy	Cloudy	Cloudy		
18.....	55	74	65.5	56	72	63	−1	2	2.5	1.2	Cloudy	Cloudy	Clear		
19.....	63	....	....	61	73.5	71	2	.....	.....	.....	Cloudy	Cloudy	Clear		
20.....	59.5	76	....	56.5	4	....	3	2	.....	.....	Cloudy	Cloudy	....		
21.....	....	68	71	....	66	70	.....	2	1	.....		Cloudy	Cloudy		
22.....	63	88	75.5	64	76	74	−1	12	1.5	4.2	Clear	Clear	Cloudy		
23.....	*	....	....	....	....	....	.....	.....	.....	.....	....	....	....		
24.....	58	74	62	57.5	74	62	0.5	0	0	0.2	Cloudy	Clear	Cloudy		
25.....	64	....	....	62.5	68	65	1.5	.....	.....	.....	Clear	Cloudy	Cloudy		
26.....	....	82.5	79	66	74	75	.....	8.5	4	.....	Clear	Clear	Cloudy		
27.....	63	87	74	64	73	70	−1	14	4	5.7	Clear	Clear	Clear		
28.....	62	89	82	60.5	75	77.5	1.5	14	4.5	6.7	Clear	Clear	Cloudy		
29.....	64	72.5	71	63	69	70	1	3.5	1	1.8	Cloudy	Cloudy	....		
Total......	....	....	....	....	....	....	0.5	347.5	111.5	143.3	....	....	....	2½	5⅛
Avg.......	....	....	....	....	....	....	0	6.1	2.1	2.8	....	....	....	.13	.27

*Records not taken.

The average daily increase varied from 0.2° to 6.7° with an average increase for the whole period of observation of 2.8°.

The differences in temperature are very unevenly distributed through the day. The greatest difference, according to the records, was obtained at noon, when it varied from nothing on a day of heavy rainfall to 14° on a very bright day, with an average for the whole period of 6.1°. The least difference was at 7 a. m., when it varied from 4.5° cooler to 3° warmer under the cover than outside. At 6 p. m. the difference in temperature varied from 0.5° cooler to 11° warmer.

EFFECT OF THE COVER ON SOIL TEMPERATURE.

The effect of the cover on the temperature of the soil was also to raise it. In this case, however, the greatest difference was in the morning, when the soil underneath the cover averaged 1.4° warmer than that in the check, the differences ranging on different mornings from 0° to 2°. Through the day the differences gradually decreased until at night it averaged only 0.1° warmer under the cover than outside.

The optimum soil temperature for most cultivated crops, according to Ebermayer as quoted by King,* is 68° to 70° F. Hence the increase in soil temperature is advantageous as long as the soil temperature is below that point and not otherwise. Examining the records of observed soil temperatures in Table II, we find that only in occasional instances during the period of observation did the soil temperature reach the optimum. Hence the increase in soil temperature may be set down as beneficial to the plant.

EFFECT OF THE COVER IN CONSERVING SOIL MOISTURE.

Soil moisture determinations were made May 22, which was after a period of protracted drought, and July 10, which was after a period of abundant rainfall, to determine the effect of the cover on the moisture content of the soil. Composite samples showed the following percentages of moisture:

	May 22.	July 10.
	Per ct.	Per ct.
Check—In row	11.0	14.4
Check—Between rows	14.4	16.9
Shaded—In row	11.6	14.5
Shaded—Between rows	14.8	17.0

*The Soil, p. 220.

These figures show slightly more moisture in the shaded than in the unshaded plat but the differences are not so great as was anticipated.

TABLE II.—SHOWING SOIL TEMPERATURES AT A DEPTH OF 3½ INCHES.

DATE.	SHADED.			UNSHADED.			DEGREES WARMER WHEN SHADED.			
	A. M.	M.	P. M.	A. M.	M.	P. M.	A. M.	M.	P. M.	Avg. per day.
	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.	Deg.F.
May 13	56	60	63.5	54	59	63	2	1	0.5	1.2
14	55.5	59	60	54	58	60	1.5	1	0	0.8
15	53.5	60	62	52	60	63	1.5	0	—1	0.2
16	53	60	63.5	51	60	64.5	2	0	—1	0.3
17	56.5	63	65	55	64	67	1.5	—1	—2	—0.5
18	57	64	66	55	64	67	2	0	—1	0.3
19	58.5	65	66	57	66	67	1.5	—1	—0.2	—0.2
20	60	65	67	60	66.5	69	0	—1.5	—2	—1.2
21	58	65.5	67	57	66	69	1	—0.5	—2	—0.1
22	61	66	67	61	67	68	0	—1	—1	—0.7
23	57	63	63	56	63	64	1	0	—1	0
24	55.5	57	60	55	56	61	0.5	1	—1	0.2
25	53	61	64	52	61.5	65	1	—0.5	—1	—0.2
26	56	58	60	55	58	60	1	0	0	0.3
27	57	62	64	56	62	64.5	1	0	—0.5	0.2
28	60	65	64.5	60	65	65	0	0	—0.5	—0.2
29	55.5	58	59.5	54	58	59.5	1.5	0	0	0.5
30	54.5	60	61.5	53	61	61	1.5	—1	0.5	0.5
31	52	59	61	50	60	62	2	—1	—1	0
June 1	53	61.5	63	51.5	63	65	1.5	—1.5	—2	—0.7
2	55	65	66	54	64	66	1	1	0	0.7
3	55	65	67	54	64	69	1	1	—2	0
4	57.5	64.5	66	57	63	66	0.5	0.5	0	0.3
5	55	62.5	68	54	61	68	1	1.5	0	0.8
6	58	63	66.5	57	61	66	1	2	0.5	1.2
7	60	65	65	58	65	64	2	0	1	1
8	61	66	67	60	66	67	1	0	0	0.3
9	61	69	68	59	68	68	2	1	0	1
10	62	65	66	60.5	64	65	1.5	1	1	1.2
11	59	64	63	57	62	62	2	2	1	1.7
12	*	....	....	....	....	....	....	....	....	....
13	56	58.5	63	54	56	61	2	2.5	2	2.2
14	56	58	....	54	56	....	2	2	....	....
15	56	60.5	63.5	54.5	58	67	1.5	2.5	—3.5	0.2
16	58	65	67	57	63	65	1	2	2	1.7
17	60.5	61	61.5	59	59	60	1.5	2	1.5	1.7
18	57	61	63	55	59	60	2	2	3	2.3
19	58	....	....	56	....	....	2	....	....	....
20	59	63	....	57	61	....	2	2	....	....
21	....	62	65	....	60	63	....	2	2	....
22	59	66	68	57	64	67	2	2	1	1.7
23	....	....	61.5	....	....	59	....	....	2.5	....
24	59	62.5	63	57	61	61	2	1.5	2	1.8
25	59	....	....	57	60	61	2	....	....	....
26	....	64	67	57	62	65	....	2	2	....
27	61	66	67	59	65	66	2	1	2	1.7
28	59	65	68	57	62.5	6	2	2.5	2	2.2
29	63	64	65	61	62	64	2	2	1	1.7
Total	....	....	....	....	....	....	61	31	4	26.3
Average	....	....	....	....	....	....	1.4	0.7	0.1	0.7

* Record not taken.

EFFECT OF THE COVER ON THE HUMIDITY OF THE AIR.

The air underneath the cover appeared to be more humid than that outside. Systematic observations were not made.

EFFECT OF THE COVER ON VELOCITY OF WIND.

Measurements were not made of the velocities of the wind under the cover and outside. There was a very great difference however. With a stiff breeze blowing outside there was not wind enough under the cover to move a sheet of paper lying on the ground. With only a fair breeze outside the air underneath was calm.

EFFECT OF THE COVER ON INTENSITY OF LIGHT.

Measurements also were not made of the intensities of the light in the two plats. There was a considerable difference in this respect nevertheless. Shadows were considerably less strong underneath than outside. Much of the light was in the form of diffused light.

EFFECT OF THE COVER ON EVAPORATION.

The comparative evaporation from the two plats was determined by direct measurement. A large, shallow dish was set level on the ground in each plat, filled with water to the brim and the depth measured with a metal rule. Measurements were made of the amount of evaporation every morning from May 12 to 25 and June 1 to 5, both inclusive. After each measurement the dishes were filled to the brim.

The record of these measurements appears in Table I. An examination of these records shows that the evaporation from an exposed surface of water in the open varied from $\frac{4}{32}$ inch to $\frac{13}{32}$ inch in 24 hours and under the cover from $\frac{3}{32}$ inch to $\frac{7}{32}$ inch. The total evaporation in the open for the nineteen days of observation was $5\frac{1}{8}$ inches, or an average of 0.27 inch per day. The total evaporation from the shaded plat was $2\frac{1}{2}$ inches, or 0.13 inch per day. The cover diminished evaporation just about one-half.

Without the aid of instruments of measurement the greatly reduced rate of evaporation under the cover was obvious, for moisture on the leaves under the cover did not evaporate nearly so rapidly as it did from leaves in the open. So much does the cover interfere with the drying off of the foliage that Mr. Gillett advises that it be removed after a rain until the leaves have become dry.

DISCUSSION.

Among the changes in environment advantageous to the plant, the great decrease in the movement of air appears to be the most important. The cover acts as a cloud, confining a layer of air underneath and protecting it in large measure from change by air currents without. This results in a greatly reduced evaporation—also transpiration as will be seen later—accompanied by an increase in temperature and in moisture content of air and of soil. The increase in temperature of the air would of itself increase evaporation while the increase in moisture content would diminish it; but far out-weighing either or both of these is the greatly reduced evaporation due to the diminished movement of the air. This decrease in evaporation accounts in part at least for the increased temperature of the soil, since evaporation is a cooling process.

The increased temperature of the air is due to the gradual accumulation of warmth in a relatively slow-changing atmosphere and this in spite of the fact that the white cover would intercept and reflect a part of the sun's rays. The increased moisture content of the air would be to some extent instrumental in preventing the radiation of the earth's heat back into space. At the same time the cover probably retards to some extent the upward movement of the warmer, lighter air underneath. The heat radiated from the earth is also conserved for the use of the plant in larger part than it is in the open.

EFFECT OF THE CHANGED ENVIRONMENT ON THE PLANT ITSELF.

The effect of the changed environment on the development of the plant itself will now be considered.

EFFECT OF SHADING ON VEGETATIVE GROWTH.

At the Station the cover was placed in position April 30, at which time the new leaves were just starting. As the season advanced it was evident that the shaded plants were making the more rapid growth.

The promotion of growth by shading showed itself to a less marked extent in the forwarding of the season of coming into bloom, as is shown in the following table:

TABLE III.—DATES OF BLOOMING OF VARIETIES OF STRAWBERRIES SHADED AND NOT SHADED.

VARIETY.	Coming into Bloom.	
	Shaded.	Not shaded.
Marshall	May 13	May 16
Brandywine	May 16	May 19
Ridgeway	May 16	May 19
Wm. Belt	May 18	May 19
Hunn	May 20	May 22

The foliage and the fruit stems, alike at Penn Yan and at Geneva, were about two inches taller under the cover than outside and the leaf expanse was proportionately greater. That is, the development was symmetrical. The shaded foliage was softer and lighter in color but apparently normal. It was in no way distorted or drawn.

Shading was of marked benefit during the drought of 1903. In the open some plants were killed and the growth of all was seriously interfered with. In the shaded plat no plants were killed by the drought, though here also growth was somewhat checked, as was evidenced by an increasingly sickly appearance before the rains came. The plants never entirely recovered from this set-back. This shaded plat made much the fuller matted rows for the reasons that the foliage made a heavier growth and that no plants were killed. Some time before the rains came in June the growth of new leaves in both plats had ceased; but when the cessation of growth in both plats had taken place the number of mature leaves per crown in the open was four in a large majority of crowns while under the cover it was five. That is, for the same number of plants there were 25 per ct. more leaves under the cover than outside. The number of leaf buds per crown appeared to be about the same in both plats.

SHADING AS A PROTECTION AGAINST FROST.

One noteworthy merit of the practice of shading is the protection it affords against frosts. Observations were made on this point in the Shortsville experiment in 1902. That year heavy frosts occurred the nights of May 9 and 10 with light frosts for two or three nights thereafter. When the frost came the clusters of buds were just showing. On May 13 the foliage under the cloth was of a healthy green and was uninjured by frost while many leaves in the check were killed and many more injured. Twelve buds in as many clusters in each of the varieties in the open were examined and all found to be injured. Under the cover no Haverland, 5 out of 12 Wilson and 10 out of 12 Jessie were injured.

At this time the buds had not developed sufficiently to permit of making extensive observations on the extent of injury to them. It was observed, however, that very few of the smaller-sized buds under the cloth showed any injury while all buds of any size not shaded were dead.

On May 22 an examination of the blossoms was made to ascertain the extent of the injury by frost. The results are shown in the following table:

TABLE IV.—EXTENT OF FROST INJURY TO SHADED AND UNSHADED STRAWBERRIES.

VARIETY.	Buds examined.	Buds injured.	Buds uninjured.	Percentage of buds injured.
				Per ct
Wilson, shaded	93	8	85	8.6
Wilson, not shaded	99	79	20	80
Haverland, shaded	154	10	144	6.5
Haverland, not shaded	142	127	15	89.4

From these data it appears that out of a total of 241 blossoms examined in the check, 206, or 85 per ct. were injured, while among 247 under the cover only 18, or 7 per ct. were injured.

Only two observations were made on the effect of shade on temperature at the time of a frost. On May 14 at 5:10 A. M. a thermometer in the check registered 30.5° and one under the cover showed 33°. On the following morning at 4:20 the temperature in the check was 28° and under the cover 33°.

EFFECT OF SHADING ON DEVELOPMENT OF DISEASE.

At the Station in 1903 no disease appeared on any variety except Hunn, in either shaded plat or check. Hunn, which is known to be very susceptible to disease, was much affected by leaf blight in both plats, but very considerably the more in the shaded plat. Mr. Gillett reports that in 1902 there was much more mildew under the shade than outside. He recommends that the cover be drawn off after a rain until excess of moisture has evaporated.

EFFECT OF THE COVER ON POLLINATION.

That the cover did not seriously interfere with pollination if it did at all, is shown by the yields, whether of perfect or imperfect varieties. Immediately after the fruit began to swell, over 200 blossom clusters were examined, both inside and outside. Those in one plat were found to be swelling as well as those in the other, proving that pollination had been sufficient and effective. Bees and other insects were observed working in abundance under the cover. One day when the wind was quite strong, perhaps twice as many insects were found in the shaded as in the check plat. The cover appeared to offer them protection.

TABLE V.—SUMMARY OF YIELDS.

VARIETY.	Shaded.	Not shaded.	Decrease by shading.
	Oz.	*Oz.*	*Per ct.*
AT GENEVA, 1903:			
Marshall	686	301	128[1]
Brandywine	442	225	96[1]
Ridgeway	880	849	4[1]
Wm. Belt	251	261	4
Hunn	247	294	19
AT PENN YAN, 1903:			
Mixed varieties	311½[2]	358½[2]	13
AT PENN YAN, 1902:			
Carmi Beauty	296	351	16
Star	99	161	39
Parker Earle	340	483	30
Enormous	144	262	45
Seaford	233	408	43
New York	70	170	59
Atlantic	305	397	23
Clyde	219	256	14
Sample	332	596	44
Glen Mary	200	347	43
Bubach	283	513	45
Beverly	330	496	34
Haverland	271	500	46
Brandywine	119	400	70
Greenville	299	510	41
Marshall / Sample	249	507	51
Average percentage of loss at Penn Yan in 1902	....	....	40
AT SHORTSVILLE, 1902:			
Wilson	744	568	31[1]
Haverland	793	469	69[1]
Jessie	275	514	47

[1] Increase. [2] Pounds.

EFFECT OF SHADING ON YIELD.

A summary statement of yields in the different experiments is made in Table V. It will be noticed that at Geneva two varieties, Marshall and Brandywine, showed a marked increase in yield as a result of shading, Ridgeway and Wm. Belt showed little effect either way and Hunn showed a decrease. Perhaps in the case of Hunn, however, the decreased yield may be due to the greater severity with which this variety was attacked by leaf blight under the cover.

The cover used at Geneva in 1903 was the one used at Shortsville the year previous. At Shortsville two varieties showed an increased yield under the cover and one showed a decrease. But it must be borne in mind that the plats in the check were severely injured by frost while those under the cover were protected. Perhaps this fact may account for a part or all of the increase apparently due to shading.

At Penn Yan all varieties showed a loss under the treatment. This is probably due to interference with access of light, for as has already been stated, the cover used was a little heavier than the one used at Shortsville and at Geneva. The loss on different varieties in 1902 ranged from 14 per ct. to 70 per ct., averaging 40 per ct. for all varieties tested. In 1903 the average loss was only 13 per ct. the variety being Sample with some admixture of Marshall and other varieties: but in 1902 the loss on a row of a nearly similar mixture of varieties was 51 per ct. The season of 1903 was dry; in 1902 moisture was abundant. It appears then that shading is far more beneficial under conditions of deficient than of abundant moisture.

Table VI.—Strawberry Yields at Geneva, 1903.

	June 4	June 6	June 8	June 13	June 16	June 19	June 22	June 25	June 27	June 30	July 3	July 6	July 11	Total yield	Avg. yield for one row	Increase in shaded plat.
	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	oz.	per ct.
Shaded:																
Marshall, 2 rows........	4	5	22	102	94	127	151	80	46	37	8			686	343	128
Brandywine, 2 rows.....				21	27	65	90	98	56	65	20			442	221	96
Ridgeway, 2 rows.......		1		16	31	114	187	204	138	139	42	9		880	440	4
Wm. Belt, 1 row........					10	42	34	56	37	43	20	9		251		4[1]
Hunn, 1 row...........							2	15	16	27	51	64	72	247		19[1]
Not Shaded:																
Marshall, 2 rows........			8	52	52	46	58	42	22	17	4			301	150	
Bradywine, 2 rows......				5	17	31	44	54	28	36	10			225	112	
Ridgeway, 2 rows.......				13	31	57	177	193	142	177	35	24		849	424	
Wm. Belt, 1 row........					8	19	43	42	32	35	37	45		261		
Hunn, 1 row...........							10	31	13	37	63	63	77	294		

[1] Decrease.

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EFFECT OF SHADING ON EARLINESS.

The effect of shading on earliness in the different tests was various but in on case marked. The yield of each variety at Geneva at each picking is shown in detail in Table VI. A casual examination of this table might lead to the conclusion that shading had increased earliness somewhat but such is not the case except with one variety. For instance 4 oz. of Marshall (30 quarts per acre) were picked June 4, and 5 oz. (37½ quarts per acre) June 6, both of which pickings were made before any pickings were made in the check. Similarly 1 oz. of Ridgeway shaded (or 7½ quarts per acre) were picked before any were ripe in the check; but all of these amounts are too small to be of practical importance. The first picking of Marshall commercially important in the open was on June 13. Taking into consideration the fact that the yield of that variety was 128 per ct. greater under the cover than in the open, and increasing the actual yield in the open up to June 13 in this proportion, the figure 136 (748 quarts per acre) is obtained, which is to be set against a total yield of 133 oz. (731 quarts per acre) in the shaded plat up to the same time. The difference is too small to consider. By similar calculations it can be shown that the ripening of Ridgeway was not hastened.

That the cover had no material influence in either hastening or retarding the ripening season of any variety in the Geneva experiment can also be shown by computing the average dates of ripening of the several varieties. It is thus shown that the average dates of ripening of Marshall, Brandywine and Ridgeway were unaffected, while that of Wm. Belt was delayed two days and that of Hunn was advanced one day. A slightly earlier maturity of all varieties would have been expected in view of the fact that the seasons of blossoming had been slightly advanced (see p. 238). The expectation was not realized, however.

At Shortsville the season of Wilson appeared to be advanced five days, that of Haverland six days and that of Jessie one day. But the unequal injury to the shaded and the check plants by frost must be borne in mind in interpreting these data, (see p. 48), All of the buds in the open that were the more advanced at the time of the frost were killed; but none of Haverland under the cover were found killed. Then, other things being equal, the shaded plants would be earlier than those in the open by just the period of time it would require to bring other buds to the stage of development reached by those killed by frost. This single consideration appears sufficient to account for the apparent increase in earliness in Haverland under the cover.

In addition it must be remembered that the foliage in the open was much injured by frost while that under the cover was entirely free from such injury.

Similarly, all of the earlier buds of Wilson in the check plat were killed but only five-twelfths of them, by estimate, in the shaded plat. In the case of Jessie, ten-twelfths of the early buds under the cover are estimated to have been killed and therewith is found an increase of only one day in apparent earliness.

It is to be concluded, then, that the earlier ripening of shaded plants at Shortsville is not due to a hastening of the physiological processes of development but merely to the utterly extraneous circumstance that the early shaded buds were protected from injury by frost while those in the open were not.

At Penn Yan, under the thicker cover, the seasons of some varieties were unaffected while those of others were retarded from one to three days. None was advanced.

EFFECT OF SHADING ON THE SIZE OF BERRY.

With the thicker cloth used at Penn Yan there was no difference in size between the shaded and the unshaded berries. With the thinner cloth used at Geneva, shading uniformly increased the size of the berry, though in very different proportions in different varieties and at different periods of the ripening season. These facts are brought out in Table VII, which shows the number of berries in carefully measured quarts of different lots from the shaded and the check plats. Thirteen quarts from each plat were examined. The total number of unshaded berries was 1452 but of shaded ones 1102 or only three-fourths as many. In every case it required more unshaded than shaded berries to make a quart. But the smaller the berries the more they settle together in the basket and the greater the actual quantity the grower has to deliver for a quart and the less he realizes from a given weight of fruit. Also, the smaller the berry the longer it takes to pick a quart. At the same time the basket of large berries with its actually smaller content, brings much the larger price in the market. Thus considering simply effect on size of berry, the practice of shading is trebly advantageous.

TABLE VII.—SHOWING NUMBER OF BERRIES PER QUART FROM SHADED AND FROM UNSHADED PLATS.

	JUNE 13.		JUNE 16.		JUNE 19.		JUNE 22.		JUNE 25.	
	Shaded.	Not shaded.	Shaded.	Not shaded.	Shaded.	Not shaded	Shaded.	Not shaded.	Shaded.	Not shaded.
Marshall..........	56	81	64	88	61	93	92	153	136	142
Brandywine.......			63	69			82	110	147	165
Ridgeway.........			63	72	56	72	85	116	83	121
Wm. Belt.........					51	57			63	113

EFFECT OF SHADING ON THE COLOR, GENERAL APPEARANCE, TEXTURE, AND QUALITY OF THE FRUIT.

Except in the first picking of some of the varieties, there was very little if any difference in the color of the berries from the two plats. In the case of the first pickings of Marshall and Ridgeway the berries from the shaded plats were a little brighter and glossier. But the effect of shading on color was not in any case enough to be of importance in practice.

The increased size of the berries under the cover added more to their general appearance than would at first be thought of as resulting from size alone. The greater the development of the receptable the smaller the number of seeds on a given area and the less is the groundwork of scarlet obscured by the dark-colored seeds. This effect was conspicuous in the first pickings of Marshall and still more so in Brandywine. In the latter variety the seeds are borne much exposed on the receptable and at best give the fruit a very rough appearance. If they are crowded together on an imperfectly developed receptable the bad appearance of the fruit is exaggerated. In the case of Brandywine the average buyer would select a box of shade-grown berries in preference to a box grown in the open. But the berries of this variety grown in the open at Geneva were of very inferior appearance.

The texture of the berries as far as eating quality is concerned was not influenced perceptibly except in the case of Marshall. In this case the shade-grown berries were softer and more melting in the mouth. As affecting shipping quality, only in the cases of Marshall and Ridgeway did the texture appear to be affected. In the case of Marshall the effect would be of little if any practical importance. But in the case of Ridgeway, naturally a rather soft berry, the shade-grown fruit would not stand shipment to distant markets though it would be all right for local trade.

As to sweetness, the first pickings from all varieties in the check at Geneva were sweeter than those shaded; but this difference practically disappeared as the bulk of the crop came on and later. The first pickings of Brandywine showed perhaps the greatest difference in this respect. Brandywines from the open were notably sweet but small. Wm. Belt showed the least difference in sweetness between the two plats. At Penn Yan no difference in sweetness between the shaded and the unshaded fruit could be detected.

Through the courtesy of Dr. L. L. Van Slyke, chemist of this Station, determinations were made by Mr. F. D. Fuller, assistant chemist, of acid and sugar in samples of Marshall and Ridgeway, shaded and unshaded, of the picking of June 19, 1903, at Geneva.

TABLE VIII.—ACID AND SUGAR CONTENTS OF SHADED AND UNSHADED STRAWBERRIES.

	Acid as malic acid.	Sugar as invert sugar.
	Per ct.	*Per ct.*
Marshall, not shaded	1.38	6.54
Marshall, shaded	1.27	6.11
Ridgeway, not shaded	1.64	6.85
Ridgeway, shaded	1.59	5.56

These results as regards acid content were surprising. The shaded berries were much the less sweet; but this was not due to the presence of more acid but of very much less sugar. There was actually a less percentage of acid in the shaded than in the unshaded fruit.

PRACTICAL RESULTS OF THE EXPERIMENT.

The practical outcome of this experiment is as follows: With the thinner cover, productiveness has been very considerably increased in the case of some varieties but decreased in others; but in no case was the increase in yield sufficient to offset the added cost of shading. With the thicker cover the yield was greatly reduced. Earliness was little affected by the cover. In the cases of some varieties under the thicker cover, ripening was retarded. In these tests the great increases, either in earliness or in yield, reported by some experimenters have not been obtained. It appears probable that a cover of thinner material, permitting the passage of more light, would give better results. The most serious objection to shading strawberries as was done in these experiments is the interference with the access of light to the plants.

We have, however, found that shading with the thinner cover improves the size of the fruit and sometimes its general appearance though at the expense of sweetness. In this respect our experience agrees with that of previous experimenters. The cover also proved a very excellent protection against frosts and light freezes, as was expected. Herein shading is a matter of insurance. But merely in so far as protection from frost is concerned, this can be obtained more cheaply in some other way.

DISCUSSION ON THE EFFECT OF SHADING ON PLANTS IN GENERAL.

Shading makes three general changes in the environment of the plant of importance to it: (1) It conserves soil moisture by lessening evaporation and transpiration; (2) it increases the temperature of air and of soil, stimulating the plant to more rapid growth; (3) it diminishes the intensity of the light, promoting the growth of aerial vegetative parts but interfering with the fruiting function.

The element of the environment that may be most widely varied by shading and at the same time the one that produces the most profound changes in both structure and functioning of the plant is light, interference with access of which is accompanied by decrease in its tonic effect in retarding growth. The consequence is an exaggerated growth of leaves and stems. Interference with access of light also interferes with assimilation, with resulting lessened manufacture of non-nitrogenous matter, this resulting in turn in weak development of cell wall and fibrovascular bundles. This latter consideration is of importance in practice, since it accounts for shaded leaves being more tender for eating. That shade grown-plants contain a smaller percentage of non-nitrogenous matter (also of total dry matter) than do normally grown plants is shown by analyses by Géneau de Lamarliére[1] Sachs[2] and Berthelot[3] among others.

Again, there is little storage of reserve material in shaded plants since the most of that manufactured is used up at once in the metabolism of the plant. As a consequence, storage organs such as tubers and roots remain undersized, or in the case of fruits their number is diminished though the size of the individual may be increased as in the case of shade-grown oranges. Fruitfulness is diminished by shading, in part at least, as a result of restricting the manufacture of reserve material. That fruitfulness is not governed by access of light to the fruiting organs themselves is demonstrated in the common practice of covering buds to avoid cross-pollination and keeping the fruit covered to its maturity.

The effect of shading in conserving soil-moisture by diminishing evaporation has already been discussed (p. 234). The general effect on transpiration is also greatly to reduce it, thus further conserving soil moisture. The factor chiefly concerned in producing the change is velocity of wind. Wiesner[4] has shown that in the case of some species of plants the rate of transpiration may be increased by a strong wind to twenty times its rate in still air. In occasional species, however, wind has the effect of checking transpiration. The extreme effect of a given velocity of wind is obtained when the current of air strikes the transpiring organ at right angles. In shading, losses from excessive transpiration caused by air currents are reduced to a very low rate. Their maximum effects are done away with entirely, since the plants are protected above all from descending currents.

The effect of reducing the intensity of light is also on the whole to reduce transpiration. In experiments by Fittbogen[5]

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[1]*Compt. Rend.*, 115: 368 (1892). Abst. in *Bied. Centbl.*, 23: 351 (1894).
[2]Cited by Vines, S. H. Physiology of Plants, p. 253.
[3]*Compt., Rend.*, 128: 139 (1899). Abst. in *Exp. Sta. Rec.*, 11: 420 (1899).
[4]*Der Naturforscher*, 21: 225. Abst. in *Bied. Centbl.*, 18: 135 (1889.)
[5]Cited by Sorauer, Pflanzenkrankheiten; 2 ed., p. 480.

shaded barley plants transpired less in the same length of time than did plants grown in the open. But the shaded plants transpired considerably more water *per gram of dry matter* than did the check plants. Further, much of the light under the cover is diffused light, as has been stated already, and plants transpire less in diffused light than in direct sunlight, as has been shown by Wiesner.[6]

GENERAL APPLICABILITY OF SHADING AS A CULTURAL PRACTICE.

The foregoing study of the effects of shading on the environment of the plant and on the plant itself renders possible general statements as to the climatic conditions and the kinds of crops to which the practice is applicable.

Shading as a means of conserving soil moisture is practically efficacious only within restricted limits. In seasons of abundant rainfall the more usual and less expensive methods of conserving soil moisture are sufficient and shading is unnecessary, assuming that exceptionally large size of the fruit is not a desideratum. In seasons of exceptional drouth, such as that of 1903 at Geneva, shading as managed in our experiments does not maintain sufficient moisture in the soil for the normal growth of the plant, though the practice is helpful to this end. But between these limits, that is under average climatic conditions, the practice is of very considerable helpfulness. It is not, however, nearly so efficacious as irrigation which, where practicable, would usually be cheaper.

As a means of raising temperatures the practice is best applicable in those seasons and in those localities where there are the largest number of bright sunshiny days; it is also most efficient in that part of the day in which the sun's rays fall most nearly from the zenith, that is, at mid-day. The practice is of little value in cloudy weather. It is of more value in the spring and early summer, when average temperatures are considerably below the optimum for growth, than in mid-summer, when this optimum is nearly or quite attained in the open.

Shading is chiefly applicable to crops grown for aerial vegetative parts. These parts grow much larger and at the same

[6]Cited by Vines, S. H., Physiology of Plants, p. 109.

time are more tender and succulent. Among crops well adapted for shading are tobacco, rhubarb, celery, lettuce, dandelion, Swiss chard and asparagus, all of which have been successfully grown under cover. But shading is not applicable to crops grown for underground vegetative parts, such as carrots, turnips and potatoes, whose economic value lies in their stored reserve material. But radishes have given good results under the treatment. In this case the root is used simply as a condiment. The practice also is not applicable to crops grown for fruits or seeds.

In conclusion, the climatic conditions to which shading as a horticultural practice is applicable are, a high percentage of sunshine, a rather light rainfall and a considerable wind with a consequent high rate of evaporation. Such conditions prevail markedly on the Great Plains and, if there are no other considerations entering in to materially affect results, shading might be expected to prove an especially beneficial practice there, particularly in middle Texas, Indian Territory, Oklahoma, Kansas, Nebraska and South Dakota.

NEW YORK APPLES IN STORAGE.*

S. A. BEACH AND V. A. CLARK.

INTRODUCTION.

This bulletin treats of different varieties of apples with regard to their natural season of ripening and keeping and their adaptability for storage. The material has been obtained from three distinctly different sources. First, from tests made at this Station on fruit which was grown in the Station orchards and stored in a small warehouse without artificial refrigeration; second, from men who have had years of practical experience in handling fruit, both in cold storage and in ordinary fruit warehouses; and third, from tests made by the United States Department of Agriculture in cooperation with this Station on numerous varieties of apples from the Station orchards in chemical cold storage, the results of which have quite recently become available.

The primary purpose of the tests which were made at this Station was to determine the ordinary season of ripening and the keeping qualities of the different varieties of apples which were being grown in the Station orchards. These tests brought out some results of general interest concerning the keeping of apples which are worthy of publication, but which are quite incomplete when regarded from the standpoint of the general adaptability of these varieties to storage purposes.

In order that we might be able to present a still more complete account of the behavior of different sorts of apples in storage than could be derived from our experiments it seemed good to consult on this subject those men who have had experience in storing apples on a large scale under commercial conditions. Accordingly, the following list of questions was sent out to a number of storage men:

VARIETY.......................

(1) How many years' experience in handling apples?

(2) Under what other names do you know this particular variety?

*A reprint of Bulletin No. 248.

How does it compare with either Hubbardston, Tomkins King, Rhode Island Greening, Baldwin or Ben Davis, (3) for holding in chemical cold storage, (4) for holding in ice cold storage, (5) for holding in common and cellar storage?

What peculiarities, if any, does it show in manner of final deterioration in chemical cold storage, such as (6) scald, (7) loss in quality, (8) color, (9) firmness before decay sets in, (10) skin becoming bitter, (11) fruit shriveling or (12) bcoming mealy or (13) bursting after becoming mealy?

(14) Does it go down in chemical cold storage gradually or quickly?

(15) At what temperature should it be held?

What is its season in (16) chemical cold storage, (17) ice cold storage, (18) cellar storage?

(19) To what extent does its keeping quality vary in different seasons?

(20) How does this variety stand heat before reaching cold storage?

The following parties responded to our circular:

J. H. Bahrenburg, Bro. & Co., New York city; 20 years experience.

W. N. Britton, of W. N. Britton & Co., Rochester, N. Y.; 27 years' experience in growing and shipping apples.

B. Fenton, of the Erie Preserving Co., Buffalo, N. Y.; over 30 years' experience in handling apples in common storage.

W. D. Graham, of W. D. Graham & Son, Minneapolis, Minn.; 40 years' experience in growing and shipping apples.

W. H. Hart, Poughkeepsie, N. Y.; 25 years' experience.

G. W. Hickox, Batavia, N. Y.; 20 years' experience.

Chas. A. Hoag, Lockport, N. Y.; 25 years' experience in growing and storing apples.

A. C. Howes, Albion, N. Y.; 30 years' experience.

Benj. Newhall, of F. Newhall & Sons, Chicago, Ill.; 25 years' experience. The house has 55 years' experience.

G. W. Payne, Rochester, N. Y.; 20 years' experience with apples in cellar storage.

Phillips Bros., Castile, N. Y.; 20 years' experience.

D. L. Prisch, Middleport, N. Y.; 15 years' experience.

J. M. Shuttleworth, Brantford, Ontario, Canada; over 30 years' experience.

T. B. Wilson, Hall's Corners, N. Y., who has many years' experience in growing apples and holding them in common storage, has read in manuscript the parts of this bulletin based on the experience of storage men and has made many suggestions.

The summary of the experience of cold storage men (pp. 258 to 277) was read in proof by the following gentlemen, who made many suggestions: D. S. Beckwith, Albion, N. Y.; A. C. Howes, Albion, N. Y.; B. Frank Morgan, Albion, N. Y.; Chas A. Hoag, Lockport, N. Y.

Chas. Shafer, Gasport, N. Y., furnished a number of notes on the comparative efficiency of ice storage and chemical cold storage.

The authors acknowledge their obligation to all these gentlemen who have so generously assisted them by filling out the circulars or by reading proof.

The recent publication by the United States Department of Agriculture of results of its tests of varieties in chemical cold storage in cooperation with this Station gave opportunity for supplementing the results of the Station's tests in natural temperature storage with tests of fruit from the same orchards in cold storage.

In 1901 and 1902 the Station furnished 109 varieties of apples, picked and packed the same, and consigned them to the Department of Agriculture at Buffalo where the tests were made by Profs. G. Harold Powell and S. H. Fulton. The results of their work are reported in Bulletin 48 of the Bureau of Plant Industry, which was issued while this bulletin was being prepared for the printer and from which the notes on these tests in this bulletin are taken. Tests with fruit from other localities were in progress at the same time but only those tests with fruit from this Station are reported in this bulletin except as otherwise noted.

THE STATION TESTS.

The Station tests were made during a period of four years with a large number of varieties (165) of apples which were stored in the Station fruit house with no artificial refrigeration. The details of this investigation were carried out by C. P. Close, then Assistant Horticulturist at this Station. As already stated the primary purpose of the tests was to find out the season of ripening of the different varieties and the length of time during which they would keep in sound condition under natural temperature conditions. The fruit which was used in these tests was all grown in the Station orchards, as was also that used in the Department cooperative tests.

THE ORCHARDS.

These orchards are located on the upland about one and one-half miles west of Seneca Lake at an altitude of about 600 feet above sea level. The trees from which most of the fruit was taken have mostly been top-grafted upon young trees of bearing age. The tops varied in age from 15 to 20 years from the graft. A few were either young trees or old trees not top-grafted. The soil is a rather heavy clay loam with heavier clay subsoil. It is thoroughly tile drained. Thorough tillage was given till mid-summer after which some cover crop was sown. The trees were well sprayed and pruned. The fruit usually was not thinned. No stable manure has been given to the trees at any time so far as is known except that one orchard of old trees was well manured in the winter of 1892-3. Acid phosphate and muriate of potash were applied in moderate amounts in 1896.

The fruit was not all picked at the same time but so far as possible the different varieties were gathered in succession in the order in which they ripened or reached suitable condition for taking from the tree and placing in storage. They were not allowed to lie in the orchard after being picked but were taken at once to the fruit house where they were stored in bushel boxes arranged in compartments which were closed with hinged covers. (Plate XIV.) There were no covers attached to the boxes. All fruit in storage at any one period was similarly treated so far as storage conditions were concerned except as already stated, that it was not all brought into storage on the same date.

THE FRUIT HOUSE.

The fruit house was designed expressly for storing small quantities of a large number of varieties of apples or pears. It was built in 1895. The building faces the north. It is of wood, 35x30 feet, one-story with a stone-wall basement having a southern exposure. The storage room used in these tests is the natural temperature room on the first floor, opening into a vestibule with entrance from the north. Adjoining it are a show room and a room for storing ice. The ice room connects with a room below and is not concerned in these tests. The studding of the walls of the building is covered both inside and outside with sheathing paper. The inside is covered with matched spruce, the outside with siding and the space filled with sawdust to the roof. Next to the sheathing boards inside is set another row of studs and these are also covered with sheathing paper and matched stuff. The space in this case is left empty for dead air space. The walls of the building are thus double, having a layer of sawdust without and a dead air space within. The floor, ceiling and interior partitions are constructed on the same principle. (See Plate XV.)

No artificial refrigeration was used. When the outside atmosphere was cooler than that in the room the windows were opened if cooler temperature was desired. A record of the temperature at 7 a. m. and 6 p. m. was kept daily from September 12, 1896, to July 13, 1897, and from October 23, 1897, to August 14, 1898. This record shows that the temperature ranged in degrees as follows:

Table I.—Showing Ranges and Averages of Temperatures in Natural Storage Room by Months for Two Seasons.

Season 1896-7.

Month.	Range.	Average, 7 a. m.	Average 6 p. m.
1896:	*Deg. F.*	*Deg. F.*	*Deg. F.*
September	42 to 74	58.0	60.2
October	37 to 63	46.0	47.6
November	29.5 to 61	44.2	45.0
December	29.5 to 45	34.4	34.8
1897:			
January	32 to 44	36.2	35.8
February	32 to 43	35.1	34.9
March	33 to 49	37.7	38.7
April	39 to 59	45.3	46.9
May	45 to 62	53.8	56.2
June	50 to 70	60.2	62.7
July	66 to 79	71.9	74.4
Season 1897-8.			
October	38 to 55	45.7	50.6
November	33 to 52	40.2	41.8
December	32 to 48	36.5	37.0
1898:			
January	31 to 39	35.5	35.3
February	33 to 42	36.0	35.9
March	32 to 52	41.2	42.3
April	32 to 52	42.7	44.8
May	42 to 67	54.3	56.6
June	55 to 74	65.2	67.6
July	53 to 80	69.8	72.9
August	63 to 78	68.9	71.0

The temperature doubtless fluctuated more slowly in the boxes where the fruit was kept than it did outside of the closed compartments, and therefore the variations in temperature experienced by the fruit itself must have been somewhat less than that shown in the records of the temperature of the fruit room.

This storage house gives very satisfactory results. The efficiency of the natural temperature room is shown exactly in the table of temperature on page 254. A comparatively low temperature can be maintained in the fall by opening the windows at night and closing them during the day. In winter a single large-burner lamp holds the temperature above the freezing point of fruit in the coldest weather, even with a strong wind blowing.

METHOD OF CONDUCTING THE TESTS.

About 100 apples of each variety were usually included in the test where this number of proper specimens could be obtained. The conditions for the different varieties were similar. At intervals of from three to four weeks the fruit was examined and those apples which were unsound or had apparently passed marketable conditions were discarded. In this manner the exact record was obtained of the length of life of each apple individually. This made it possible to determine the average life in storage of each variety and the date to which the average period of life extended under the existing conditions.

VARIETIES IN THE STATION TESTS, ARRANGED CHRONOLOGICALLY ACCORDING TO AVERAGE LIFE.

In the following lists are shown the varieties used in the Station tests. They are arranged in the chronological order of average lives beginning with the earliest, and for convenience grouped by half-months except in the case of the few varieties whose average life fell in October:

Varieties whose average life fell in October:

Gracie,	Parry,
Keswick,	Strode.

Varieties whose average life fell in the first half of November:

English Pippin,	Chenango,
Alexander,	Pomona,
Pound Sweet,	Stump.

Varieties whose average life fell in the last half of November:

Boskoop,
Elgin,
Pumpkin Russet,
Jersey Sweet,
Krimtartar,
Haskell,
Longfield.

Varieties whose average life fell in the first half of December:

Ohio Pippin,
Heidorn,
Gravenstein,
Longworth,
Tufts.

Varieties whose average life fell in the last half of December:

Haas,
Ostrakoff,
St. Lawrence,
Tobias,
Washington Strawberry,
Romna,
Ginnie.

Varieties whose average life fell in the first half of January:

Admirable,
Tobias Pippin,
Magog,
Aucuba,
Gideon,
Disharoon.

Varieties whose average life fell in the last half of January:

Jefferis,
McMahon,
Stanard,
Twenty Ounce,
Blenheim,
Mother,
Wolf River,
Fameuse,
Crotts,
Henniker,
Jewett *Red*,
McIntosh.

Varieties whose average life fell in the first half of February:

Pomme Grise,
Clarke,
Victoria,
Hurlbut,
Kalkidon,
Rhodes,
Pumpkin Sweet,
Barbel,
Wealthy,
Peter,
Jacobs Sweet,
Flory,
Fall Pippin.

Varieties whose average life fell in the last half of February:

Milligen,
Pewaukee,
Northern Spy,
Falix,
Brownlee,
Greenville,
Maiden Blush,
Etowah,
Cogswell,
Grimes,
Fall Wine,
Lansberg,
Jonathan Buler,
Celestia,
Dickinson,
Borsdorf.

Varieties whose average life fell in the first half of March:

Sharp,
Peach,
Hubbardston,
Smith *Cider,*
Milden,
Tompkins King,
Duke of Devonshire,
Reinette Pippin,
Marigold,
Yellow Bellflower,
Tolman *Sweet,*
Buckingham,
Northwestern *Greening,*
Swenker,
Melon,
Domine,
Dumelow,
Rambo,
Canada Baldwin,
Ornament.

Varieties whose average life fell in the last half of March:

Canada Reinette,
Esopus *Spitzenburg,*
Farris,
Monmouth,
Moon,
Scott,
Red Russet,
Golden Russet,
Golden Medal,
Peck *Pleasant,*
Sutton,
Coon,
Rhode Island *Greening,*
Washington Royal,
Ronk,
Wallace Howard.

Varieties whose average life fell in the first half of April:

White Pippin,
Kansas Greening,
Menagère,
Holland,
Mann,
Jonathan,
Olive,
Swaar,
Caux,
White Doctor,
Ewalt,
Salome,
Streaked Pippin,
Arkansas,
Duncan,
Kittageskee,
Walbridge.

Varieties whose average life fell in the last half of April:

Moore Sweet,
Lankford,
Yellow Forest,
Newtown Spitzenburg,
Occident,
Ontario,
Fallawater,
Roxbury,
Rome,
Lady Sweet,
Vanhoy.

Varieties whose average life fell in the first half of May:

Kansas Keeper,
Gideon Sweet,
Cooper Market,
Lawver,
Chase,
Wagener,
York Imperial,
Newman,
Texas,
Large Lady,
Baldwin.

Varieties whose average life fell in the last half of May:

Jones,	Winesap,
Edwards,	Ben Davis,
Stark,	Zurdel,
Kirtland,	Nelson.
Ralls,	

Varieties whose average life fell in the first half of June:

Green Newtown,	Andrews,
Pifer,	Red Canada.

The average life of Schodack extended to July 18.

It is important to remark that the date to which the average life of the fruit in storage extended does not necessarily coincide with the date when the fruit of that particular variety was half gone. Thus 100 specimens of Arkansas were put into storage October 14, 1897. On November 23, 8 were discarded; on December 20, 4; on February 1, 4; on March 4, 15; on March 22, 5; on April 4, 14; on April 21, 1; on May 6, 8; on May 24, 9; on June 11, 28; on June 30, 6. The average life of the fruit from the time it was put into the storage extended to April 12, but the fruit was half gone on April 4. Neither does the average life coincide necessarily with the commercial limit.

EXPERIENCE OF STORAGE MEN.

A summary of the information gained from practical storage men is presented under the following heads:

Conditions affecting the keeping quality of apples.

Comparative efficiency of different kinds of storage as applied to different varieties.

At what temperature should different varieties be held?

Relation between seasonal differences and keeping quality.

Kinds of deterioration that may precede rotting in storage, and varieties liable to each:

1. Scald.
2. Loss in quality.
3. Change in color.
4. Loss in firmness.
5. Becoming bitter.
6. Shriveling.
7. Becoming mealy.
8. Bursting.

9. Rapidity of going down.
   (a) List of those that go down gradually.
   (b) List of those that go down quickly.
10. Endurance of heat after picking and before going into storage.
    (a) List of those enduring heat comparatively well.
    (b) List of those not enduring heat well.

CONDITIONS AFFECTING KEEPING QUALITY OF APPLES.

The keeping quality of apples is influenced by many conditions, among which are the ripeness of the fruit, season, manner of picking, packing and handling, kind of storage, presence of fungi and temperature at which the fruit is stored. Overgrown specimens do not keep so well as those of medium size. Morgan remarks that thick-skinned varieties generally keep better than thin-skinned ones.

Keeping quality is often correlated with degree of coloring up of the fruit. To keep best, colored apples should be picked only after they are well colored but while they are still firm. According to Wilson, this point is reached when the plump seeds are black. But in order to keep longest in *cold* storage Rhode Island *Greenings* must be picked while they are still very green and hard. They will then carry through without any scald until very late in the season. But Rhode Island *Greenings* appear to hold best in *common* storage when they have ripened well on the tree, as is Wilson's experience (see p. 319). According to Howes Rhode Island *Greenings* are in condition for picking for longest holding in *cold* storage when the bloom on the fruit rubs off easily and leaves the skin rather shiny. This rule is said to apply less markedly to Baldwins and probably to other varieties.

Methods of harvesting, packing and handling in transportation have the greatest influence on keeping quality. Handlers of apples sometimes roll barrels of fruit, allowing them to strike against other barrels. This rough handling may bruise the fruit almost to the midde of the barrel. But some varieties are more easily injured by rough handling than are others. Northern Spy is one of the easiest to bruise and barrels are often found to go down in storage early on this account. Tolman *Sweet* and Yellow Bellflower are other varieties very sensitive to rough handing.

Storage men emphasize and reiterate the point that cold storage can only be successful when fruit is handled very carefully—more carefully than fruit is now often handled. At the same time it is important that only No. 1 fruit be stored. Not only is there little profit in storing No. 2 fruit, but when it goes on the market it hurts the sale of No. 1 fruit.

The seasons given in this bulletin for the different varieties are for fruit carefully picked, packed and otherwise handled according to the most approved methods.

Certain differences in the management which the trees receive result in corresponding differences in the keeping quality of the fruit. For example, apples grown in sod attain to a higher color and keep longer than those grown under clean culture.

The soil on which the tree grows makes a difference with the keeping quality of the fruit. Baldwins grown on sandy or gravelly soil ripen earlier and must be picked earlier and do not keep so well as those on clay soils, although they have a higher color.

The presence of fungi is liable to shorten the life of fruit. Fameuse and many other varieties when affected by scab keep very poorly in storage. Fruit affected by certain other fungi keeps well until it reaches a certain stage of ripeness and then goes down quickly. Beckwith finds that if Baldwins are very badly affected by fungus, they hold longest in cold storage if picked quite green. Fruit affected with fungus keeps best in a cold dry atmosphere. This point was clearly brought out by experience in 1902.

But except for retarding the development of fungus, apples keep best with considerable moisture in the air. Such is the opinion of many storage men, among them Hoag and Beckwith. Hoag remarks that Roxburys, especially, keep much better if they are rather damp.

In recent years cold storage men have generally come to believe that apples should go into storage as soon as picked. With the Hubbardston, however, Wilson still believes that it is best to let the fruit lie on straw on the ground for two or three weeks for the purpose of adding color to the fruit. This can be done, perhaps, with this variety because it is not a good variety for storing anyway and goes soon into consumption. But cold storage men are agreed that, although this practice may put the fruit in better condition for immediate use, it injures its keeping quality.

Some varieties, as McIntosh, ripen very unevenly. If all the fruit is picked from a tree of such a variety at one picking, there results a mixed lot of differing degrees of ripeness, and the season of the ripest fruits determines the season of the whole lot. The harvesting of such varieties should be divided between two or more pickings. In parts of the west, it has become an established practice to pick some varieties of apples in the same way that peaches and oranges are picked, going over the trees a number of times and taking each time only those fruits that have reached the required degree of ripeness. As a result the different fruits in any such lot are very uniform in keeping quality and the percentage of No. 1 fruit is greatly increased. The small packages used by Oregon fruit-growers for their apples and the high prices obtained for the fruit make the practice profitable there.

Some growers have, in the last few years, adopted the practice of picking early apples, especially Oldenburg, in this way, and the practice is gaining. In this case the earliness of the season gives time for several pickings; but when the main crop of fruit comes on it must be harvested all at once in order to get through picking in time. Although the desirability of making two or more pickings is commonly admitted it does not seem to be generally practicable under present conditions and methods of apple orcharding in New York State. The practice is for the grower of early or fancy fruit or of fruit for local markets rather than for the growers of the ordinary commercial varieties of winter apples. Yet there is a feeling, especially among dealers, that this is a coming practice.

It is a matter of common observation that specimens that are very large for the variety do not keep so well as those of medium size and firmer texture. This is remarked by several cold storage men. Such fruit may be produced on young trees or on mature trees making excessive growth or carrying a light crop.

COMPARATIVE EFFICIENCY OF DIFFERENT KINDS OF STORAGE AS APPLIED TO DIFFERENT VARIETIES.

The efficiency of the various kinds of storage as applied to different varieties differs greatly. For instance, according to Hart, the season of both Fallawater and Grimes in cellar storage is January; but the season of Fallawater in chemical cold storage is May, a lengthening of the season by four months, while the season of Grimes in chemical cold storage is February, a prolongation of the season of only one month.

Again, the season of Missouri *Pippin* and York Imperial in cellar storage is given by Newhall as December; but that of Missouri *Pippin* under ice is April, a prolongation of the season by four months, while the season of York Imperial is extended only one month or until February.

Nor is there any constant difference for all varieties in their season in storage under ice and in chemical cold storage. For instance, Graham gives the season of both Baldwin and Hendrick in storage under ice as May 1; but he gives the season of Baldwin in chemical cold storage as June 15, or an increase of one and one-half months, while the season of Hendrick is stated as May 15, or an increase of only one-half month.

As to the difference in season of varieties in cellar and in chemical cold storage, Howes makes this uniformly 60 days, *i. e.* two months for all varieties. Newhall makes it one month for five (early fall) varieties, two months for 19 varieties, three months for 23 varieties, four months for eight varieties and five months for Northwestern *Greening*. Graham makes this difference variously from $\frac{5}{6}$ month to three months. Hart makes this difference two months in a large majority of cases, with extremes of one and four months. The seasons of the varieties reported on by Newhall, Graham or Hart in the different storages, as given by these parties, is shown in Table II.

TABLE II.—SEASONS OF CERTAIN VARIETIES OF APPLES IN VARIOUS STORAGES.

Variety.	As reported by	Season in: Chemical cold storage.	Season in: Ice storage.	Season in: Cellar storage.	Difference in season between: Cellar and ice storage.	Difference in season between: Ice and chemical storage.	Difference in season between: Cellar and chemical storage.
					Mos.	*Mos.*	*Mos.*
Alexander	Newhall	Nov.	Nov.	Oct.	1	0	1
Baldwin	Graham	June 15	May 1	April 1	1	1½	2½
Baldwin	Hart	May	April	March	1	1	1
Ben Davis	Graham	July 1	June 1	April 1	2	1	3
Black Gilliflower	Graham	Mch. 1	Feb. 15	Feb. 1	½	½	1
Blue Pearmain	Newhall	May	April	Feb.	2	1	3
Blue Pearmain	Graham	Dec. 15	Dec. 1	Nov. 20	⅓	½	⅚
Boiken	Newhall	May	April	Feb.	2	1	3
Canada Baldwin	Newhall	May	April	March	1	1	2
Cooper Market	Newhall	May	May	March	2	0	2
Cooper Market	Graham	July 1	June 15	April 1	2½	½	3
Cranberry Pippin	Newhall	April	March	Dec.	3	1	4
Domine	Newhall	Jan.	Dec.	Oct.	2	1	3
Domine	Graham	Mch. 1	Feb. 15	Feb. 1	½	½	1
English Russet	Newhall	April	March	Dec.	3	1	4
English Russet	Hart	June	June	April	2	0	2
Esopus *Spitzenburg*	Graham	June 15	June 1	May 1	1	½	1½
Esopus *Spitzenburg*	Hart	March		Jan.			2
Fallawater	Newhall	April	March	Jan.	2	1	3
Fallawater	Graham	Mch. 30	Mch. 20	Mch. 1	⅔	⅓	1
Fallawater	Hart	May		Jan.			4
Fall Orange	Newhall	Sept.	August	3 days			
Fall Pippin	Newhall	Nov.	Nov.	Oct.	1	0	1
Fall Wine	Newhall	Oct.	Sept.	5 days			
Fameuse	Newhall	Dec.	Dec.	Oct.	2	0	2
Fameuse	Graham	April 1	Feb. 15	Feb. 1	½	1½	2
Gano	Newhall	May	April	Jan.	3	1	4
Gano	Graham	June 15	June 1	April	2	½	2½
Gideon	Newhall	Feb.	Jan.	Nov.	2	1	3
Golden Russet	Graham	August	July	May	2	1	3
Gravenstein	Newhall	Feb.	Jan.	Dec.	1	1	2
Green Newtown	Hart	April		Feb.			2
Grimes	Newhall	Feb.	Feb.	Dee.	2	0	2
Grimes	Graham	Mch. 30	Mch. 1	Feb.			
Grimes	Hart	Feb.		Jan.			1
Haas	Graham	Jan. 15	Jan 1	Dec.			1
Hendrick	Graham	May 15	May 1	April 1	1	½	1½
Holland Pippin	Newhall	Nov.	Nov.	Oct.	1	0	1
Hubbardston	Newhall	March	Feb.	Dec.	2	1	3
Hubbardston	Graham	Jan. 15	Jan. 1	Dec.			
Hubbardston	Hart	Jan.		Dec.			1
Jacobs Sweet	Hart	March		Dec.			3
Jonathan	Newhall	Feb.	Jan.	Nov.	2	1	3
Jonathan	Hart	March		Jan.			2
Keswick	Newhall	Nov.	Oct.	Sept.	1	1	2
Lady	Newhall	Jan.	Dec.	Nov.	1	1	2
Lady Sweet	Hart	June		April			2
Lawver	Newhall	April	April	Feb.	2	0	2
Limbertwig	Newhall	May	May	Feb.	3	0	3
Maiden Blush	Newhall	Nov.	Nov.	Oct.	1	0	1
Maiden Blush	Graham	Dec. 15	Dec. 1	Nov.			
May-Seek-no-farther	Graham	May 1	April 15	Mch. 1	1½	½	2
McIntosh	Hart	Jan.		Nov.			2
Minkler	Newhall	May	April	Jan.	3	1	4
Missouri *Pippin*	Newhall	April	April	Dec.	4	0	4
Missouri *Pippin*	Graham	July 1	June 1	April 1	2	1	3
Northern Spy	Hart	April	March	Feb.	1	1	2

TABLE II.—SEASONS OF CERTAIN VARIETIES OF APPLES IN VARIOUS STORAGES.—*Concluded.*

VARIETY.	As reported by	SEASON IN			Difference in season between		
		Chemical cold storage.	Ice storage.	Cellar storage.	Cellar and ice storage.	Ice and chemical storage.	Cellar and chemical storage.
					Mos.	*Mos.*	*Mos.*
Northwestern *Greening*	Newhall	May	April	Dec.	4	1	5
Oldenburg	Newhall	Sept.	Sept.	Sept.			
Peck *Pleasant*	Newhall	April	March	Jan.	2	1	3
Peck *Pleasant*	Hart	March	Feb.	Jan.	1	1	2
Perry Russet	Newhall	March	Feb.	Nov.	3	1	4
Pewaukee	Newhall	Feb.	Jan.	Nov.	2	1	3
Pewaukee	Graham	May 1	Apr. 15	March			
Pewaukee	Hart	March		Jan.			2
Plumb Cider	Newhall	Jan.	Dec.	Oct.	2	1	3
Pomme Grise	Newhall	March	Feb.	Jan.	1	1	2
Pumpkin Sweet	Newhall	Feb.	Jan.	Nov. 30			
Ralls	Newhall	May	April	Feb.	2	1	3
Rambo	Newhall	Feb.	Jan.	Nov.	2	1	3
Red Canada	Newhall	April	March	Feb.	1	1	2
Rhode Island *Greening*	Newhall	Feb.	Feb.	Dec.	2	0	2
Rhode Island *Greening*	Hart	April	March	Feb.	1	1	2
Ribston	Newhall	Feb.	Dec.	Nov.	1	2	3
Ridge	Newhall	Jan.	Dec.	Oct.	2	1	3
Roman Stem	Newhall	Jan.	Jan.	Nov.	2	0	2
Roman Stem	Graham	April 15	April 1				
Rome	Newhall	May	April	Feb.	2	1	3
Rome	Graham	July 1					
Roxbury	Hart	May		April			1
Salome	Newhall	May	April	Jan.	3	0	3
St. Lawrence	Newhall	Dec.	Nov.	Oct.	1	1	2
Shiawassee	Hart	Dec.	Nov.	Sept.	2	1	3
Smith *Cider*	Newhall	May	April	March	1	1	2
Stark	Newhall	May	April	Feb.	2	1	3
Sutton	Hart	March	Feb.	Jan.	1	1	2
Swaar	Newhall	March	Feb.	Dec.	2	1	3
Swaar	Graham	April 1					
Swaar	Hart	Feb.	Jan.	Dec.	1	1	2
Tolman *Sweet*	Newhall	March	Feb.	Jan.	1	1	2
Tolman *Sweet*	Hart	April		Jan.			3
Tompkins King	Newhall	Feb.	Dec.	Oct.	2	2	4
Tompkins King	Hart	March	Feb.	Jan.	1	1	2
Twenty Ounce	Newhall	Jan.	Dec.	Nov.	1	1	2
Wagener	Newhall	March	Feb.	Dec.	2	1	3
Walbridge	Newhall	May	April	Feb.	2	1	3
Wealthy	Newhall	Jan.	Dec.	Oct.	2	1	3
Winesap	Newhall	April	April	Feb.	2	0	2
Winter Banana	Newhall	April	March	Dec.	3	1	4
Yellow Bellflower	Newhall	Jan.	Dec.	Nov.	1	1	2
Yellow Bellflower	Graham	Feb. 25	Feb. 1	Jan.			
Yellow Bellflower	Hart	March	March	Dec.	3	0	3
Yellow Newtown	Newhall	April	March	Feb.	1	1	2
Yellow Newtown	Graham	April 1	Feb. 20	Feb. 1	⅔	1⅓	2
York Imperial	Newhall	Feb.	Jan.	Dec.	1	1	2

As to the relative efficiency of cellar and ice storage as applied to different varieties, Newhall reports that the season of 19 varieties is prolonged by ice storage one month beyond their season in cellar storage, 28 varieties two months, and eight varieties three months and two varieties four months. Graham gives the prolongation of season as from ½ month to 2½ months for different varieties. Hart reports this difference as one month for seven out of nine varieties.

As to the relative efficiency of storage under ice and of chemical cold storage, Newhall assigns the same season in either storage to 14 varieties. In the case of 40 varieties Newhall finds that chemical cold storage lengthens the season by one month as compared with storage under ice and in the case of two varieties the season is lengthened two months. Hart reports 7 varieties as keeping one month longer in chemical than in ice storage. Graham assigns to one-half of the varieties he reports on a lengthening of the season by ½ month in chemical storage, but in other cases this difference varies from ½ month to 1½ month.

Shafer estimates the life of fruit in chemical cold storage as 60 days longer than the same varieties under ice, though in very cool seasons such as that of 1903 there is, he says, hardly any difference in the keeping quality of the fruit in the two storages.

Ice storages have several disadvantages. After warm fruit is put in, it takes some time to get it cooled off and in the meantime the ripening process is going on. The temperature cannot be held so low as it can with mechanical refrigeration, 38° to 40° being about the temperature in an ice storage, which however is held quite even at this temperature. Then about one-third of the air space in the building is occupied by the ice storage. So far as large commercial operations are concerned, ice storage is a thing of the past. It is a significant fact that no new ice storages are being put in.

AT WHAT TEMPERATURE SHOULD DIFFERENT VARIETIES BE HELD?

Some correspondents appear to hold all varieties at about the same temperature, while others vary the temperature according to the variety. While practices differ in individual cases a general principle can be detected running through and guiding practice in general. It is, that varieties that keep long and go down slowly are held at about 31° to 32°, while early ripening varieties and those that do not keep so well are held one or two degrees higher, that is, at 33° to 34°. In a few cases shorter lived varieties are held at lower temperature than the long lived ones, that is, at a little under 32°.

The early apple, when held at a low temperature, loses in quality when it comes out of storage it goes down quicker than if held at the higher temperature. Moreover, some fruit as, for instance, that of the ordinary Twenty Ounce, freezes at a higher temperature than does other fruit like the ordinary Baldwin, and for this reason aside from others must be held higher.

It is well known that very large specimens of a given variety do not keep so well as medium sized or small ones. Newhall makes practical application of this fact in that he holds average sized Rhode Island *Greenings* at 32° but large ones at 33°; also in that while he commonly holds Hubbardstons at 33°, if the fruit is under size it is held at 32°. On the contrary, Morgan and others hold all fruit of the same variety at the same temperature irrespective of size.

Howes holds all varieties reported on at 32°. Similarly Hart holds all varieties for which this question is answered at 30° to 32° except Hubbardston which is held at 30°. Graham holds most varieties at 32° but a few at 33°. Newhall holds most varieties at 32° or 33°, but summer and early fall varieties as high as 34° or even 35°. Phillips Bros. hold at various temperatures, ranging from 30° to 35°. The varieties on which each of these parties reported on temperature are shown in Table III with the respective temperatures reported. Fenton reports on Baldwin, Ben Davis, Northern Spy, Rhode Island *Greening,* Tompkins King and Twenty Ounce, recommending that each be held close around 32°. Beckwith agrees with the recommendations of temperatures for all varieties in Newhall's list with which he has had experiences and to that list adds Baldwin, Ben Davis, Black Gilliflower and Roxbury, all to be held at 32°.

TABLE III.—TEMPERATURES AT WHICH VARIETIES ARE HELD BY GRAHAM, HART, HOWES, NEWHALL AND PHILLIPS.

	W. D. Graham & Son.	W. H. Hart.	A. C. Howes.	F. Newhall & Sons.	Phillips Bros.
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
Alexander				33–34	
Bailey	32				32
Baldwin	32	30–32	32		30–32
Ben Davis	32	30–32	32		
Black Gilliflower	32		32		32
Blue Pearmain	32			32	
Boiken				32	
Canada Baldwin				32	
Cooper Market	32		32	32	32
Cranberry Pippin				32[1]	
Domine	32–33			33	
English Russet				32	33
Esopus *Spitzenburg*	32		32		31
Fallawater	32			32–33	32
Fall Orange				34–35[2]	
Fall Pippin				34[2]	
Fall Wine				34–35	
Fameuse	32–33			33	
Gano	32	30–32		32	
Gideon				34	
Golden Russet	32		32		
Gravenstein	33		32	32–33	
Grimes	33			32	
Haas	33				
Hendrick	32				
Holland Pippin			32	34[2]	31–32
Hubbardston	33	30	32[3]	33[4]	
Jonathan				32	
Keswick				34	
Lady				32	
Lawver				32	
Limbertwig				32	
Maiden Blush	33		32	33[5]	
May Seek-no-farther	32				
Minkler				32	
Missouri *Pippin*	32[6]			32	
Northern Spy		30–32	32		32
Northwestern *Greening*				32	
Oldenburg			32	34[2]	
Peck *Pleasant*			32	32	
Perry Russet				33	
Pewaukee	32[6]			33	
Plumb Cider				33	
Pomme Grise				33	
Pumpkin Sweet				33	
Ralls				32	
Rambo	32			33	
Red Canada				32	
Rhode Island *Greening*		30–32	32[7]	32[8]	
Ribston				32–33	
Ridge				33	
Roman Stem	32			33	
Rome	32			32	
Roxbury			32		32–34
Salome				32[9]	
St. Lawrence			32	33[9]	
Shiawassee				33–3	
Smith *Cider*				32	
Stark				32	
Swaar	32	30–32	32	32	32
Tolman *Sweet*			32	32	33–35
Tompkins King		30–32	32	33	32
Twenty Ounce			32[10]	34	30–32
Wagener			32	32	
Walbridge				32	
Wealthy				33	

[1] "If of average size, 33° if large." [2] "If held at all." [3] Should be held even [4] "32° if under medium size." [5] "Usually." [6] "As nearly as possible." [7] "Should be held even." [8] "If of average size, 33° if large." [9] "If held at all." [10] "For short season."

TABLE III—(*Concluded*).

	W. D. Graham & Son.	W. H. Hart.	A. C. Howes.	F. Newhall & Sons.	Phillips Bros.
	Deg. F.	*Deg. F.*	*Deg. F.*	*Deg. F.*	*Deg. F.*
Westfield *Seek-no-further*					32
Winesap				32	
Winter Banana				32	
Yellow Bellflower	32		32	33–32	32
Yellow Newtown	32–33			32	
York Imperial				32–31	

RELATION BETWEEN SEASONAL DIFFERENCES AND KEEPING QUALITY.

It is well known that apples vary much in keeping quality in different seasons. It is also a common observation that they keep much better if the month of October is cool than if it is warm. This fact is often remarked, especially by Fenton, Howes and Graham. Fenton remarks that Baldwins keep four to six weeks longer in cellar storage if the month of October is cool than if it is warm. Similarly Northern Spy keeps a month longer.

Howes remarks that apples keep better after a dry season than a wet one. "But," he continues, "the season of 1902 was a wet one and still apples kept as well as any season. This of course refers only to apples not affected by any disease."

Beckwith remarks that the best growing season for apples is a rather cool summer with plenty of rain the first part of the season and dry, *even* weather the latter part, as in 1903. Apples grown such seasons keep best.

Some varieties, such as Hubbardston, Northern Spy and Twenty Ounce do not color up well some seasons and Russets may not become well russeted. In both cases the result is the same as when fruit is picked too green and put into storage. Its keeping quality is very much lessened. But Morgan remarks that highly colored Hubbardstons go to pieces in storage quicker than those not so highly colored; and Beckwith observes that, contrary to general experience, Roxburys were as good in quality in 1903 as usual though they were very green.

Some varieties, as Maiden Blush, vary greatly in time of maturing in different seasons. The earlier the fruit matures, the less satisfactory it is as a keeper. (Howes.)

Various fungous diseases are much worse some seasons than others. Fruit affected by fungus cannot be expected to keep like clean fruit. "Baldwins affected by fungus will hold as put in storage until they reach a certain degree of maturity and then begin to rot." (Howes.)

The quicker fruit is put into refrigeration the less bitter rot, pinkrot and other diseases can develop.

The following varieties are reported by Howes as being comparatively little affected by differences of season:

Cooper Market,
Roxbury,
Tolman *Sweet*,
Tompkins King,
Yellow Bellflower.

Graham mentions Missouri *Pippin* as being in this category.

The following varieties are reported by Howes as being more affected in keeping quality by differences in season than are most varieties:

Holland Pippin,
Hubbardston,
Maiden Blush,
Northern Spy,
Rhode Island *Greening*,
St. Lawrence,
Twenty Ounce.

In this category Hart mentions Swaar and Graham mentions Fameuse.

KINDS OF DETERIORATION THAT MAY PRECEDE DECAY IN COLD STORAGE, AND VARIETIES LIABLE TO EACH.

Under the following sub-heads are given lists of varieties reported as showing certain peculiarities of behavior in deterioration in chemical cold storage.

In examining these lists it should be borne in mind that varieties often differ greatly in their manner of deterioration in different kinds of storage and under different conditions. These lists by no means indicate the unanimous experience of our correspondents. Not infrequently experiences run entirely counter to each other.

VARIETIES LIABLE TO SCALD IN STORAGE.

But few apples will scald if left on the tree until they get their color, remarks Graham, though any variety will scald if picked earlier. This of course does not apply to green fruit such as Rhode Island *Greenings*. But in the case of Baldwin, Wilson's experience is that it is less liable to scald if picked early, that is as soon as the plump seeds are black, than if it is left on the tree longer to get a deeper color. On the other hand "late picked Rhode Island *Greenings* withstand scald much longer in dry storage than do those early picked." (Wilson.) But as has been already noted (p.259), in order to keep best in chemical cold storage Rhode Island *Greenings* should be picked quite green.

Scald appears on the shaded side of the apples first. Susceptibility to scald increases with the progress of the ripening process in cold storage. Contrary to a popular impression, the investigations of the United States Department of Agriculture have shown that scald develops more freely in a temperature of 36° to 38° than in one of 32°.

Graham remarks that Baldwins will scald after May 1 unless put into storage *immediately* after picking.

The following varieties are reported as scalding, sometimes early, sometimes only late in their season, and in same cases but little:

Baldwin,
Ben Davis,
Canada Baldwin,
Cooper Market,
Fallawater,
Gano,
Gilpin,
Grimes,
Hubbardston,
Lady,
Maiden Blush,
Mann,
May Seek-no-farther,
Minkler,
Missouri *Pippin*,
Northern Spy,
Peck *Pleasant*,
Pewaukee,
Rhode Island *Greening*,
Ridge,
Rome,
Smith *Cider*,
Stark,
Swaar,
Tolman *Sweet*,
Tompkins King,
Twenty Ounce,
Wagener,
Walbridge,
Winesap,
Winter Banana,
Yellow Bellflower,
York Imperial.

VARIETIES ESPECIALLY LIABLE TO LOSE IN QUALITY IN GOING DOWN IN COLD STORAGE.

Most varieties lose in quality before decay sets in. The following have been particularly mentioned as doing so:

Alexander,
Black Gilliflower,
Blue Pearmain,
Boiken,
Canada Baldwin,
Cranberry Pippin,
Domine,
Fallawater,
Fall Pippin,
Fall Wine,
Fameuse,
Gideon,
Grimes,
Haas,
Holland Pippin,
Hubbardston,
Jonathan,
Keswick,
Lady,
Maiden Blush,
Minkler,
Northwestern *Greening,*
Oldenburg,
Peck *Pleasant,*
Perry Russet,
Pewaukee,
Plumb Cider,
Pomme Grise,
Pumpkin Sweet,
Rambo,
Rhode Island *Greening,*
Ribston,
Ridge,
Rome,
Salome,
Shiawassee,
St. Lawrence,
Smith *Cider,*
Stark,
Swaar,
Tolman *Sweet,*
Tompkins King,
Twenty Ounce,
Wagener,
Walbridge,
Wealthy,
Winter Banana,
Wolf River,
Yellow Bellflower.

CHANGE IN COLOR IN STORAGE.

Many varieties change in color in common storage, especially by turning from green to yellow. Holland Pippin, Swaar, Tolman *Sweet* and Yellow Bellflower impove in color. Apples in which the prevailing colors are shades of red and the ground color green or yellow may be brightened in color by the development of the yellow tints, which also makes the red brighter by contrast. Thus, Cooper Market turns from its autumn color of dark red to an attractive bright red in May in cellar storage but not in chemical cold storage. (Britton.) On the other hand both greens and yellows may become pale and faded. " St. Lawrence, unless well colored on the tree, fades in the barrel to a distinctly gray color, materially lessening its market value." (Britton.)

The following varieties are reported as either eventually liable to lose in color in storage, or to lack the improvement in color when kept in cold storage which they commonly show in cellar storage:

Canada Baldwin,
Cooper Market,
Gano,
Grimes,
Hubbardston,
Lady,
Maiden Blush,
Minkler,
Missouri *Pippin,*
Peck *Pleasant,*
Rhode Island *Greening,*
Ridge,
Rome,
St. Lawrence,
Smith *Cider,*
Wagener,
Walbridge,
Winesap,
Winter Banana,
York Imperial.

VARIETIES LOSING IN FIRMNESS IN GOING DOWN IN STORAGE.

Most varieties lose in firmness before going down in storage. The following have been particularly mentioned as having this fault:

Black Gilliflower,
Blue Pearmain,
Canada Baldwin,
Domine,
Esopus *Spitzenburg,*
Fallawater,
Fall Orange,
Fall Wine,
Gano,
Gideon,
Gravenstein,
Grimes,
Haas,
Hubbardston,
Jacobs Sweet,
Keswick,
Lady,
Lady Sweet,
Minkler,
Missouri *Pippin,*
Peck *Pleasant,*
Perry Russet,
Pewaukee,
Plumb Cider,
Pumpkin Sweet,
Rambo,
Ridge,
Rome,
Roxbury,
St. Lawrence,
Shiawassee,
Smith *Cider,*
Stark,
Wagener,
Walbridge,
Wealthy,
Winter Banana,
Wolf River,
Yellow Bellflower.

VARIETIES LIABLE TO BECOME BITTER IN SKIN IN GOING DOWN IN STORAGE.

The following varieties are reported to be liable to become bitter in skin in going down in storage:

Alexander,
Baldwin,
Boiken,
Cranberry Pippin,
Esopus *Spitzenburg,*
Gano,
Gilpin,
Haas,
Lady,
Minkler,
Perry Russet,
Pewaukee,
Pomme Grise,
Ralls,
Rhode Island *Greening,*
Ridge,
Rome,
St. Lawrence,
Smith *Cider,*
Stark,
Swaar,
Tolman *Sweet,*
York Imperial.

VARIETIES LIABLE TO SHRIVEL IN GOING DOWN IN STORAGE.

The varieties named below have been reported as normally liable to shrivel in going down in storage or before. Many other varieties shrivel if picked too green.

Blue Pearmain,
Boiken,
English Russet,
Esopus *Spitzenburg,*
Fallawater,
Golden Russet,
Haas,
Hubbardston,
Jonathan,
Lady Sweet,
McIntosh,
Peck *Pleasant,*
Perry Russet,
Pewaukee,
Pumpkin Sweet,
Ralls,
Rambo,
Roxbury,
St. Lawrence,
Swaar,
Tolman *Sweet,*
Westfield *Seek-no-further.*

VARIETIES LIABLE TO BECOME MEALY IN GOING DOWN IN STORAGE.

Many varieties become mealy in storage but only a few enough so to hurt their value in the markets. A large Baldwin is liable to become mealy but not an average sized one. The following varieties are particularly reported as becoming mealy in going down in storage:

Baldwin,
Ben Davis,
Black Gilliflower,
Blue Pearmain,
Cranberry Pippin,
Domine,

Esopus *Spitzenburg*,
Fall Orange,
Fameuse,
Gano,
Gideon,
Grimes,
Haas,
Hendrick,
Holland Pippin,
Hubbardston,
Maiden Blush,
Oldenburg,
Perry Russet,
Pewaukee,
Pomme Grise,
Pumpkin Sweet,
Ralls,
Rambo,
Rhode Island *Greening*,
Ridge,
Rome,
Roxbury,
St. Lawrence,
Smith *Cider*,
Stark,
Tolman *Sweet*,
Tompkins King,
Twenty Ounce,
Wagener,
Wealthy,
Yellow Bellflower.

VARIETIES LIABLE TO BURST IN STORAGE BEFORE DECAYING.

Any apple that will scald is liable to burst, says Howes. A large fruit of any variety is more liable to burst than a medium sized one. The following varieties are reported as being liable to burst as the fruit goes down in storage:

Baldwin,
Black Gilliflower,
Domine,
Fall Orange,
Fameuse,
Gideon,
Haas,
Hendrick,
Holland Pippin,
Hubbardston,
Maiden Blush,
Oldenburg,
Plumb Cider,
Pomme Grise,
Pumpkin Sweet,
Ralls,
Rambo,
Rhode Island *Greening*,
Ridge,
Roman Stem,
St. Lawrence,
Smith *Cider*,
Stark,
Wagener,
Yellow Bellflower.

SUDDENNESS OF GOING DOWN IN STORAGE.

The varieties named below are reported as going down gradually in storage. It will be noticed that most of the varieties in this list are late or mid-winter varieties:

Baldwin,
Black Gilliflower,
Blue Pearmain,
Boiken,
Canada Baldwin,
Cooper Market,
Cranberry Pippin,
Domine,

English Russet,
Fallawater,
Gano,
Gilpin,
Grimes,
Hendrick,
Jonathan,
Lady Sweet,
Lawver,
Limbertwig,
Maiden Blush,
Mann,
Minkler,
Missouri *Pippin,*
Northwestern *Greening,*
Peck *Pleasant,*
Pewaukee,
Pomme Grise,
Ralls,
Rambo,
Red Canada,
Rhode Island *Greening,*
Ridge,
Roman Stem,
Rome,
Roxbury,
Salome,
Shiawassee,
Smith *Cider,*
Stark,
Sutton,
Swaar,
Tolman *Sweet,*
Tompkins King,
Walbridge,
Winesap,
Winter Banana,
Yellow Bellflower,
Yellow Newtown.

The varieties in the following list are reported as going down quickly. It will be noticed that they are nearly all fall or early winter varieties. In general, the earlier the season of the variety the more rapidly does it go down after final deterioration has set in. Some of these varieties are named also in the preceding list of varieties that go down gradually. This repetition simply expresses the differing experiences or judgments of different correspondents:

Alexander,
Bailey,
Black Gilliflower,
Domine,
Esopus *Spitzenburg,*
Fall Orange,
Fall Pippin,
Fall Wine,
Fameuse,
Gideon,
Golden Russet,
Gravenstein,
Grimes,
Haas,
Holland Pippin,
Hubbardston,
Jacobs Sweet,
Keswick,
Lady,
Maiden Blush,
Northern Spy,
Oldenburg,
Perry Russet,
Pewaukee,
Plumb Cider,
Pomme Grise,
Pumpkin Sweet,
Rambo,
Ribston,
Ridge,

St. Lawrence,
Tompkins King,
Twenty Ounce,
Wagener,
Wealthy,
Wolf River,
Yellow Bellflower,
York Imperial.

ENDURANCE OF HEAT BY DIFFERENT VARIETIES AFTER HAVING BEEN PICKED AND BEFORE GOING INTO STORAGE.

Varieties differ greatly in endurance of heat after having been picked and before going into storage. Summer and early fall varieties are most affected in this respect and late-keeping varieties least. In order to keep longest in cold storage apples should be exposed to heat for as short a time as possible after having been picked.

Varieties listed below are reported as standing heat comparatively well before going into storage. Those which stand heat best are among the latest.

Baldwin,
Ben Davis,
Black Gilliflower,
Blue Pearmain,
Boiken,
Canada Baldwin,
Cooper Market,
Cranberry Pippin,
Domine,
Esopus *Spitzenburg,*
Fallawater,
Fameuse,
Gano,
Gilpin,
Golden Russet,
Green Newtown,
Hendick,
Jonathan,
Lady Sweet,
Lawver,
Limbertwig,
Mann,
Minkler,
Missouri *Pippin,*
Ontario,
Plumb Cider,
Pomme Grise,
Pumpkin Sweet,
Ralls,
Rambo,
Red Canada,
Roman Stem,
Rome,
Roxbury,
Salome,
Smith *Cider,*
Stark,
Sutton,
Swaar,
Tolman *Sweet,*
Tompkins King,
Walbridge,
Westfield *Seek-no-further,*
Winesap,
Winter Banana.

In the next list are shown the varieties which are reported as being much affected by heat. This list includes all the summer and early fall apples concerning which reports on this point were made, and most of the late fall and early winter apples. But some winter apples are also comparatively sensitive to heat, as Rhode Island *Greenings* and Northern Spy. In the case of some varieties heat induces scald or sweat spot.

Alexander,
Bailey,
Blenheim,
Fall Orange,
Fall Pippin,
Fall Wine,
Gideon,
Gravenstein,
Grimes,
Haas,
Holland Pippin,
Hubbardston,
Jacob Sweet,
Keswick,
Lady,
Maiden Blush,
McIntosh,
Northern Spy,
Northwestern *Greening,*
Oldenburg,
Peck *Pleasant,*
Perry Russet,
Pewaukee,
Rhode Island *Greening,*
Ribston,
Ridge,
St. Lawrence,
Shawassee,
Twenty Ounce,
Wealthy,
Wagener,
Wolf River,
Yellow Bellflower,
Yellow Newtown,
York Imperial.

NOTES ON VARIETIES.

In preparing these notes on varieties the plan has been to give in one paragraph the results of the tests of the keeping quality of apples in the natural temperature storage at this Station made in the seasons of 1895-6 to 1898-9, inclusive; in the next paragraph are the results of the tests of the keeping qualities of varieties grown at this Station, made in a cold storage warehouse in Buffalo by the Unites States Department of Agriculture; and in the last paragraph is a summary of the experience of cold storage men with the respective varieties. In some cases a general estimate of the variety for storage purposes is made in a preliminary paragraph.

Referring to results obtained at this Station, the term "Commercial limit," means, unless otherwise specified, the time to which dealers may safely hold a given variety in natural temperature warehouses under conditions similar to those which obtained in these tests. Referring to results of tests in cold storage, the term means similarly the time to which the variety may be held in such storage.

In the notes on tests at the Station are given the seasons in which each variety was tested, the number of fruits stored, their average life for all seasons tested and the mean date of deterioration of last fruits of the variety. These results, as already stated, are obtained with fruit grown in the Station orchards and may not apply exactly to fruit from other localities.

ADMIRABLE (*Small Admirable*). In the Station tests fruit was stored in 1895, '96, '97 and '98. The mean dates were September 27 for storing; January 1 for average life; May 4 when last apples went out. The crop of 1897 kept much the best, otherwise results were fairly uniform indicating that under the existing conditions the season for this variety is November and December.

ALEXANDER (*Wolf River* incorrectly). This is an early fall apple and is not often put into storage.

In Station tests 60 apples were stored September 9, 1897. The average life extended to November 4, the last fruit being thrown out January 12.

In the experience of storage men its season in cellar storage is until October and in chemical cold storage until November. It goes down quickly and does not stand heat well before going into storage. It should be shipped the day it is picked and under ice.

American Blush (of some; see HUBBARDSTON).

AMERICAN BLUSH. Hart reports that this variety as disseminated by C. A. Green of Rochester is entirely distinct from Hubbardston. Season about the same as Baldwin. It is a little inclined to scald. See note on Hubbardston.

AMOS (*Amos Jackson*). In the Department cold storage tests small, hard and green fruit from this Station, stored September 27, was still firm and free from scald or rot May 1.

Amos Jackson (see AMOS).

ANDREWS (*Andrews Winter*). In the Station tests fruit from the crops of 1895, '96 and '97 was stored. The average number tested was 83. The mean dates were October 19 for storing; June 8 for average life; August 16 when the last apples went out. The results were pretty uniform indicating that the season may extend to the middle of May or sometimes into June. With two crops a considerable portion of the fruit remained sound till the middle of June.

Andrews Winter (see ANDREWS).

Arkansas (*Blacktwig, Mammoth Blacktwig*). In the Station tests this fruit was stored October 14, 1897; average life extended to April 12; last fruit went out June 30.

Aucuba (*Aucuba-leaf Reinette*). In the Station tests fruit borne in 1895, '96, and '97 was stored. The mean dates were September 25 for storing, January 8 for average life and May 5 when last fruit went out. Results were fairly uniform, indicating that the season extends to December or possibly to January.

In the Department cold storage tests bright, well-colored fruit from this Station, stored October 21, kept sound and in good condition until February 1.

Aucuba-leaf Reinette (see *Aucuba*).

Aunt Ginnie (see Ginnie).

Bailey (*Bailey Sweet*). A poor keeper and does not stand heat well.

Baker (*Scott*). In the Department cold storage tests hard, greenish fruit from this Station, stored September 29, kept firm and sound in cold storage until March 14, after which it softened.

Baldwin. A leading variety for cold storage purposes, ranking in season between Rhode Island *Greening* and Ben Davis.

In the Station tests fruit of 1895, '96, '97 and '98 was stored. The mean dates were October 13 for storing; May 10 for average life; June 29 when last fruits went out. Results variable but indicate that under the conditions of the tests the season may extend through April. With two crops a considerable portion of the fruit remained sound till early June.

In the Department cold storage tests hard, light-colored, small fruit from this Station, stored October 15, was still hard and sound May 1.

According to storage men its season in cellar storage is until March or April, varying from February 15 in unfavorable seasons (Fenton) to June 1 in favorable seasons (Payne). Season in chemical cold storage until May or June. Graham states that the fruit will hold until June if well colored on the tree, but only until April if colored on the ground. It goes down gradually with some liability to scald late in the season, Phillips Bros. specifying March and later in common storage and Graham May 1 and later in chemical cold storage "unless stored immediately after picking." Wilson says Baldwin is less liable to scald if picked as soon as the plump seeds are black than if left on the tree until it get its full color. Moreover in the latter case much of the crop would be lost besides putting off picking until very late in the fall. Beckwith remarks that a gray Baldwin grown on the heavy soil of the Lake Ontario shore keeps longer than any other Baldwin. The higher-colored Baldwins grown on sandy or gravelly land are said to scald earlier. Large specimens are liable to become mealy (Howes) and scald and burst (Wilson, Morgan) but those of medium size only rarely.

Barbel (*Sugar Barbel*). In the Station tests fruits from the crops of 1895 and '96 were tested, the average number under observation each season being 77. The mean date of storing was October 1, of average life February 7 and of decay of last fruits June 12. Decay began in November and proceeded gradually through the season.

Belle de Boskoop (see Boskoop).

Bellflower (see Yellow Bellflower).

Ben Davis. This variety holds well in any storage and its value for storage purposes is enhanced by the facts that it retains its fine appearance and stands handling well after coming out of storage. New York-grown Ben Davis hold considerably later in the season than do Ben Davis from warmer latitudes.

In the Station tests fruit grown in 1895, '96, '97 and '98 was stored. The mean dates were October 20 for storing; May 29 for average life; August 3 when last apples went out. The results were quite uniform indicating that the season may extend into May.

In the Department cold storage tests hard, small, light-colored fruit from this Station, stored November 12, was still semifirm and free from scald and decay May 1.

Storage men report its season in common storage as extending to April and in chemical cold storage until July 1. It stands heat fairly well before going into storage and goes down slowly, becoming mealy and scalding slightly at the last, according to some correspondents. Fenton reports that it shrivels late in the season in common storage. Graham remarks, "Some persons claim this variety should be held at 31° but we have had best results at 32°."

In the Department cold storage tests fruit from this Station, stored September 27, was firm and free from decay May 1, but slightly scalded. Commercial limit April 1.

BLENHEIM (*Blenheim Pippin, Blenheim Orange*). "Earlier than Hubbardston or Tompkins King. Heat ripens it quickly, but in a moderately cool season it ranks high in its class as a shipper." (Shuttleworth.)

In the Station tests apples grown in 1898 and '97 were stored. The average number tested was 52. The mean dates were October 7 for storing; January 21 for average life; and June 12 when the last fruit went out. Season early winter extending possibly as late as middle of January.

BLACK GILLIFLOWER (*Gilliflower*). Storage men report its season in cellar storage as extending to February 1 (Howes, Graham) or April (Payne) and in chemical cold storage till March 1. It stands heat before going into storage quite well. After having become decidedly mealy it goes down slowly according to some, while others say quickly. Howes adds that it loses in quality and firmness and often bursts.

Blacktwig (see ARKANSAS).

BLUE PEARMAIN (*Prolific Beauty* incorrectly). Keeps in cold storage about with Rhode Island *Greening*. It is an old variety, but not much grown in this State except in the northern counties.

Newhall gives its season in cellar storage as February, and in chemical cold-storage as May, while Graham gives these dates as November 20 and December 15, respectively. It stands heat fairly well. and goes down in storage gradually after having lost in firmness. Newhall states that it also loses in quality and becomes mealy but does not shrivel, all of which is contrary to the experience of Graham and others.

BOIKEN. Storage men report its season in cellar storage as extending until February and in chemical cold storage until May. It stands heat before going into storage very well. It goes down gradually, losing in quality, the skin becoming bitter and the fruit shriveling.

BORSDORF. German name BORSDORFER. In the Station tests 104 apples were stored October 9, 1897. The average life extended to February 28 and the last fruit went out June 11.

In the Department cold storage tests fruit from this Station, stored September 27, was soft and badly decayed March 14.

BOSKOOP (*Belle de Boskoop*). In the Station tests, September 20, 1895, 50 apples and September 30, 1896, 40 apples went into storage. The mean date for the average life was November 17 and the mean date when the last apples went out was January 20 indicating that the season extends into October or under favorable conditions into November. It sometimes keeps till April.

BROWNLEE (*Brownlee Russet*). In the Station tests fruit was stored in 1896 and '97. The mean dates were October 19 for storing; February 19 for average life; and June 9 when last fruit went out. The results indicate that the season extends into January or possibly into February.

BUCKINGHAM. In the Station tests 104 apples were stored October 5, 1896. The average life extended to March 9, and the last fruit went out July 12.

CABASHEA (*Cabashaw; Twenty Ounce Pippin* of some). A large coarse apple, season of Tompkins King.

CANADA BALDWIN. Ranks about with the New York Baldwin in keeping quality.

In the Station tests apples of the crops of 1896 and '97 were stored. The mean dates were October 8 for storing; March 14 for average life; and June 3 when last fruit went out. The results were very similar in both years indicating that the season may extend through February.

Storage men report its season as extending in cellar storage to March and in chemical cold storage to May. It stands heat comparatively well before going into storage and goes down gradually after having scalded and lost in quality and color and having softened.

Canada Pippin (see WHITE PIPPIN).

Canada Red (see RED CANADA).

CANADA REINETTE. At the Station, fruit of the seasons of 1896 and '97 was tested. The mean dates were October 20 for storing; March 17 for average life; and June 27 when last fruits went out. The figures for the two seasons vary greatly but indicate that under favorable conditions the fruit may be held until March.

In the Department cold storage tests this variety from this Station, stored October 19, was mellow and free from decay, but slightly scalded May 1. Best commercial limit April 1.

CAUX (*Reinette de Caux*). At the Station, fruit of the seasons of 1896, '97 and '98 was tested. The mean dates were October 17 for storing; April 8 for average life; and June 24 when last fruits went out. Averages for the different years differ greatly. The average life in 1896 and '97 extended only till about the middle of March while in '98 it extended till the latter part of May. The indications are that this variety usually may be held till March.

Cayuga Red Streak (see Twenty Ounce).

Celestia. In the Station tests 61 apples were stored October 1, 1896, and 104 apples October 8, 1897. The mean date for average life was February 25 and for the discarding of the last fruit was June 3. There was much difference in the keeping quality of the fruit in these two years, indicating that its season may vary greatly. It may be expected to extend into January; it may possibly extend through the winter.

Chase (see Hyde King.)

Chenango (*Chenango Strawberry, Sherwood Favorite*). In the Station tests 105 apples were stored September 2, 1896. The average life extended to November 8. This variety ripens unevenly on the tree and therefore two or more pickings should be made of fruit intended for storing. The latest ripening fruit may be kept till November. After that it deteriorates much in quality even when the fruit is apparently sound.

Christmas Apple (see Lady).

Clarke. In the Station tests 30 apples were stored October 5, 1896, and 105 apples October 9, 1897. The mean dates were February 2 for average life, and April 11 when the last fruit went out.

In the Department cold storage tests this variety from this Station, stored October 21, was mellow and free from scald but slightly decayed February 1; commercial limit December 1. Flesh grows soft and mealy and discolors at end of commercial life.

Codlin (see Keswick).

Cogswell. In the Station tests 48 apples were stored October 1, 1896. The average life extended to February 22. The last apples went out June 30. About 20 per ct. of the fruit went out during the first month of storage. The remainder kept well till the first of February after which it went out gradually.

In the Department cold storage tests this variety from this Station, stored October 11, was firm and free from scald and decay May 1.

Cooper Market. This is one of the latest-keeping varieties grown but is otherwise valuable principally on account of its productiveness and bright color late in the season. Some consider this one of the best commercial kinds to supply the trade after the Baldwin season.

In the Station tests apples of the crops of 1895, '96 and '97 were stored. The mean dates were October 20 for storing, May 2 for average life and August 6 when last fruit went out. Comparatively little fruit went out before the middle of May after which it went down pretty rapidly although in one instance some specimens were kept till the first of September. The results were pretty uniform and in conformity with the known late keeping qualities of this variety.

In the Department cold storage tests this variety from this Station, stored October 21, was still hard and sound May 1.

Cold storage men report its season in cellar storage variously as extending to April 1 or July 1 and in chemical cold storage to May 1, July 1 or the year around.

It stands heat before going into storage as well as any variety and goes down gradually without developing any undesirable qualities unless scald. Britton remarks, "No other variety I have ever seen improves so much in color while in the barrel as Cooper Market." Its natural color as picked is dark red but in common storage it takes on a bright red in May. In cold storage this change does not take place but the fruit remains dark red.

Cox Pomona (see Pomona).

Cranberry Pippin. This variety as grown in western New York sometimes keeps through the winter but ranks rather below Baldwin in keeping quality. As grown in the Hudson Valley its season is one month to six weeks earlier than Hubbardston and Tompkins King.

Season in cellar storage until December or January and in chemical cold storage until April. It stands heat fairly well before going into storage and goes down gradually after having lost in quality, softened, become mealy and the skin having become bitter.

Crotts. In the Station tests 104 apples were stored October 16, 1897. The average life extended to January 28 and the last fruit was discarded June 30. It kept well till the first of February and then went down pretty rapidly till the last of March, after which the remaining fruit went out gradually.

In the Department cold storage tests fruit from this Station, stored October 21, was firm and free from decay March 14, but badly scalded.

Deacon Jones. In the Department cold storage tests fruit grown at this Station, stored October 11, was mellow but free from rot and scald May 1. Commercial limit for barrel storage about March 1.

Dickinson. This variety appears to be quite variable in keeping quality.

In the Station tests fruit from the crops of 1895, '96 and '97 was stored. The mean dates were October 8 for storing; February 27 for average life; and June 11 when the last fruit went out. The fruit of 1895 and '96 showed a rather high rate of loss from the middle of November throughout the winter; but the fruit of 1897 showed but small percentage of loss before the first of February. Through February, March and April it went out rather slowly and after that went down rapidly. It appears that ordinarily it would be best not to hold it much later than the first of January.

In the Department cold storage tests bright, No. 1 fruit from this Station, stored September 27, was overripe and badly decayed May 1. Commercial limit in 1901-2, March 1; in 1902-3, February 1.

Disharoon. In the Station tests 50 specimens were put in storage September 17, 1896, and 69 specimens September 29, 1897. The mean dates were September 23 for storing; January 11 for average life; and May 12 when last fruit was discarded. The results were similar in both years. There was a gradual loss of fruit from November till the close of the season. For commercial purposes it appears that the fruit should not be kept later than December.

In the Department cold storage tests, sound, No. 1 fruit from this Station, stored September 27, was sound and free from scald and decay April 1 but beginning to turn mellow.

Doctor (*Coon, Coon Red*). Fruit attractive bright red. Apparently well adapted for storage.

In the Station tests fruit from the crops of 1896, '97 and '98 was stored. An average of 84 specimens was put under test. The mean dates were October 10 for storing; March 26 for average life; and June 9 when the last fruit went out. The results were pretty uniform. The fruit kept till about March 1 with comparatively little loss, after which it went down gradually.

In the Department cold storage tests this variety from this Station stored September 28 was semifirm and free from decay, but slightly scalded May 1. Commercial limit March 15.

DOMINE (*English Redstreak, Wells*). In the Station tests fruit grown in 1896 and '97 was tested. The mean dates were October 13 for storing; March 13 for average life; and June 8 when last apples went out. The results of both tests were similar. The fruit kept till February with but small loss. After the middle of February it went down more rapidly, indicating that here its commercial season would not extend beyond February.

Two reports were received from storage men on this variety and they are widely at variance with each other. Graham reports that it stores very well; season in cellar storage February 1, and in chemical cold storage March 1. Newhall reports that it is inferior to Hubbardston in keeping quality, seasons October and January in the respective storages. Graham reports that it stands heat before going into storage very well and goes down in storage gradually without having previously lost in quality, become soft or mealy or having burst, all of which is contrary to Newhall's experience. Tests of the keeping quality of this fruit at this Station rather agree with Graham's experience, for its average life extended to March 9 and 16, respectively, two seasons.

DUKE OF DEVONSHIRE. In the Station tests fruit was stored from the crops of 1896 and '98. The mean dates were October 1 for storing; March 5 for average life; and May 1 when last fruit went out. The results of both tests were similar. The fruit kept well till about the first of February and then went out rapidly, although a few straggling specimens remained till March and in one instance till June. The commercial limit appears to be about February 1.

DUMELOW (*Wellington*). In the Station tests 107 specimens were stored October 23, 1896. The average life extended to March 13 and the last fruit was discarded July 12. By the middle of February about 25 per ct. of the fruit had gone out. About 35 per ct. remained till after the first of May.

Duncan. In the Station tests fruit from the crops of 1895, '96 and '97 was stored. The mean dates were October 17 for storing; April 13 for average life; and July 4 when the last apples went out. The crop of 1895 did not keep well. But that of 1896 and '97 sustained the reputation of this variety for excellent keeping qualities. In these years the rate of loss was low till the first of May, after which the fruit went out rather fast. Thirty-five per ct. of the crop of 1895 was gone by January 1, yet 37 per ct. of it remained sound till the first of April. It appears that the commercial limit would ordinarily extend till the first of May.

Edgar Red Streak (see Walbridge.)

Edwards. In the Station tests fruit from the crops of 1895, '96 and '97 was stored. The mean dates were October 19 for storing; May 19 for average life; and August 24 when the last fruit went out. Previous to the first of May the rate of loss was low. After that it rose rapidly. Some specimens may often be kept till apples come again.

In the Department cold storage tests hard, green fruit from this Station, stored September 27, was quite mellow but free from scald or rot March 14.

Elgin (*Elgin Pippin*). In the Station tests apples from the crops of 1896 and '97 were stored. The mean dates were September 8 for storing; November 18 for average life; and January 26 when last fruit went out. Both tests gave similar results. The commercial season evidently closes before November.

English Pippin. In the Station tests 105 apples went into storage September 1, 1896. The average life extended to November 3 and the last fruit went out January 12. Commercial limit October.

English Russet (*Golden Russet* incorrectly). This is one of the longest keeping apples grown commercially.

Season in cellar storage April and in chemical cold storage June to July. It stands heat before going into storage extra well, and goes down very slowly after having shriveled. Newhall reports on a fall apple under this name which may be the English Russet of Warder.

Esopus *Spitzenburg* (*Spitzenburg*). Ranks between Rhode Island *Greening* and Baldwin as a keeper. It is quite variable in keeping quality in different seasons and different localities.

In the Station tests apples from all four crops were stored. The average number that went into storage was 128. The mean dates were October 11 for storing; March 21 for average life; and June 19 when last fruit went out. The crop of '95 kept exceptionally poorly while that of '98 kept exceptionally well. The commercial limit varied with the different seasons from January to April.

In the Department cold storage tests, No. 1 fruit from this Station, stored October 27, was semifirm and free from decay and scald May 1. In barrels should be sold April 1.

Cold storage men report its season as extending in cellar storage until February and in chemical cold storage until March (Hart) or June 15 (Graham). Some report it as going down quickly in storage after having become soft, shriveled and sometimes mealy and the skin bitter, all of which is contrary to the experience of other correspondents.

ETOWAH. In the Station tests 105 apples went into storage October 8, 1897. The average life extended to February 22, and the last fruit went out June 3. After the first of December there was a low rate of loss till the first of March when the fruit went on very rapidly.

EWALT. In the Station tests 51 specimens were put in storage September 30, 1896, and October 11, 1897, 102 specimens. The mean dates were April 10 for average life and July 6 when last fruit was discarded. For the crop of 1897 the rate of loss was low and gradual from the last of November till the middle of May after which the fruit went out very rapidly. The commercial limit appears to vary from the first of March to the first of May.

In the Department tests well-colored, No. 1 fruit from this Station, stored October 11, was beginning to mellow March 14 with slight decay but no scald. Commercial limit in barrels Feb. 1.

FALIX. In the Station tests 86 specimens were put into storage October 14, 1897. The average life extended to February 17, and the last fruit was discarded June 11. From the middle of November till the middle of March the rate of loss was pretty uniform and rather high, indicating that it would not be well to hold this variety much later than the first of January.

FALLAWATER (*Tulpehocken*). Ranks sometimes with Hubbardston and sometimes with Rhode Island *Greening* in keeping quality. It is quite variable in this respect.

In the Station tests fruit of all four crops was tested. Average number under test 84. The mean dates were October 12 for storing; April 26 for average life; and July 15 when last fruit was discarded. Occasionally the fruit keeps pretty well through the winter with but little loss as did the crop of 1897. But as a rule there is a continuous loss at a rather low rate from about the middle of November to the middle or last of March after which the fruit goes out very rapidly, as was the case with the crops of 1895 and '96.

In the Department cold storage tests, No. 1, but very green, fruit from this Station, stored October 21, was semifirm, and tree from decay or scald May 1.

According to cold storage men its season in cellar storage extends to January or to March 1 and in chemical cold storage to April 1 or May. It stands heat quite well before going into storage and goes down gradually after having scalded, softened and shriveled according to some correspondents but not in Graham's experience.

Fall Orange. This is an early fall variety and should not be put into storage. Cars should be iced. In cellar storage specimens are sometimes kept in quite good condition until midwinter.

Fall Pippin. This is a fall variety and should not go into storage.

At the Station this variety was under observation all four seasons. The mean date of storing was September 25; of average life February 13; and of going out of last specimens May 8. The crop does not ripen uniformly. Some of the fruit is ripe, well-colored and ready for immediate use in September while at the same time a considerable portion of the crop is still hard and green. In these tests, of course, the early-matured fruit was not stored. With that which was stored the results were quite variable in the different seasons. The highest loss before December 1 was 21 per ct. With different crops from 22 per ct. to 46 per ct. went down before February 1. Even carefully selected fruit cannot be relied upon to hold to December 1 without considerable loss.

In the Department cold storage tests bright, No. 1 fruit from this Station, stored September 29, 1902, had commenced to soften

January 27. Fruit picked in 1901 kept in good condition until January 10. May be held in boxes until February 1.

Season in cellar storage is given by storage men as September to October and in chemical cold storage as October and November. It goes down quickly. Cars should be iced.

Fall Queen (see HAAS).

FALL WINE (*Autumn Strawberry*). This is a fall variety and should be handled direct to the consumer.

In the Station tests fruit of the crops of 1895, '96 and '97 was put in storage. The mean date of storing was September 18; of average life February 23; and of discarding the last specimen June 7. With the crop of 1895 the average life extended only till January 4, but in the case of the crop of '97 till April 4. The fruit usually kept well through October but in one case did not. There was always a heavy loss in November and with one exception in December also, after which it was less but constant till the end. Commercial season September and October.

FAMEUSE (*Snow*). This is a fall and early winter apple, but some report that it will keep in cold dry storage, if free from scab, as long as Rhode Island *Greening*.

At the Station, fruit of the crops of 1885 and '96 was under observation. The mean date of storing was October 3, of average life of the fruit January 28, and of decay of the last specimen April 29; but there was a great difference in the keeping quality of the fruit in the two seasons, the average life of the crop of 1896 being three months longer than the crop of 1895, according to our records. The larger part of the fruit of 1895 decayed before January 1, but the crop of 1896 kept fairly well till the middle of January then went down more rapidly. In both cases there was considerable loss in November. Commercial season November.

In the Department cold storage tests, hard, bright, No. 1 fruit from this Station, stored October 21, was mellow, but free from decay or scald January 31. It was still sound though very ripe March 14.

Cold storage men report that it stands heat very well before going into storage and that it goes down gradually, not scalding until late but becoming mealy and bursting.

FARRIS. Fruit grown in 1895 and '96 was tested at the Station. For 1895 the average life of the fruit was February 7, and the last specimens were thrown out May 28. For 1896, however, the average life was May 1, and the last specimens were not thrown out till June 30. In 1895 decay began early in the fall and proceeded moderately through the year. With the crop of 1896 it set in in January and proceeded very moderately till April, when it proceeded very rapidly. The season for this variety appears to be variable but may extend to February or March.

FISHKILL. In the Department cold storage tests, large, sound, well-colored fruit from this Station, stored October 11, began to decay internally, while still firm outside, after January 1 or 15.

FLORY. Observations were made at the Station on the crops of 1895, '96 and '97. The average date of storing was September 30, of life of the fruit February 13, and of decay of the last specimens July 18. The averages for all the years are quite uniform. Its season may be said to extend to February. The fruit goes down very slowly at first but rather rapidly toward the latter part of the season.

GANO. This variety is reported by storage men to be practically identical with Ben Davis so far as keeping qualities in storage are concerned.

In the Department cold storage tests, small, hard, half-colored fruit from this Station, stored October 1, was semifirm but somewhat decayed May 1. Commercial limit April 1.

Newhall reports its season in cellar storage as extending until January and in chemical cold storage until May. It stands heat well before going into storage and goes down gradually. It scalds, loses in color and firmness in deteriorating, becomes mealy and the skin sometimes becomes bitter.

Genet (see RALLS).

GIDEON (*Gideon White*). Inferior to Hubbardston in keeping quality. After this variety reaches maturity the flesh characteristically begins to discolor at the core.

Observations were made at the Station on the crops of 1895, '96 and '97. The mean date of storing was September 17; of average life January 11; and of decay of last specimens May 13. This variety differed widely in keeping quality in the different seasons. In season October to December but may sometimes keep till February. The variety usually goes down rather moderately.

Storage men report its season as extending in cellar storage to October or November and in chemical cold storage until November to February. They report that it stands heat poorly before going into storage and that it goes down quickly after having lost in quality, softened, become mealy and having burst.

Gideon Sweet. Fruit stored October 5, 1896, at the Station, showed an average life extending to May 1, the last fruits being thrown out July 12. The fruit went down gradually.

Gilliflower (see Black Gilliflower).

Gilpin (*Little Red Romanite*). "A very late keeper, keeping well in any kind of storage. Some bury it in the ground like potatoes and take it out in the spring." (Graham.)

Ginnie (*Aunt Ginnie*). Fruit of the crops of 1895, '96 and '97 was tested at the Station. The average number of specimens under test was 68. The mean dates were September 24 for storing; December 28 for average life; and May 11 when last fruit went out. There was a high rate of loss during October, November and December, after which the apples then remaining went out gradually. Commercial season September to November.

Golden Medal. Fruit of the crops of 1896 and '97 was tested at the Station. The mean dates were October 8 for storing; March 24 for average life; and July 22 for discarding the last specimens. The crop of 1896 showed a high percentage of loss in November and December, after which it went out gradually. But the crop of 1897 did not show a high rate of loss before the middle of May. It then went down rapidly.

Golden Russet (of Western New York). This variety was formerly much sought after for the latest use; but since the introduction of cold storage and of highly-colored late keeping varieties such as Ben Davis its value has been much lessened.

Fruit from all of our crops was tested at the Station. The average number of apples stored was 165. The mean dates were October 15 for storing; March 23 for average life; and July 2 for discarding the last fruit. The results were variable with the different tests. The crops of 1895 and '98 lost a comparatively high percentage of fruit before the first of January after which the rate of loss was low till May when it again became high. The crops of 1896 and '97 on the contrary, showed a comparatively low rate of loss through the winter and in one case kept remarkably well till after the first of May.

In the Department cold storage tests hard, greenish russet, No. 1 fruit from this Station, stored November 15, was in prime commercial condition and free from decay May 1. June 1, the fruit was mellow and decay was setting in.

Storage men report its season as extending in cellar storage variously to March 1, or to June and in chemical cold storage to May or to August. It stands heat very well before going into storage according to most of our correspondents. It is said to shrivel and go down quickly when once decay has begun. Wilson remarks that the less the russeting, the shorter lived the fruit.

Gracie. September 1, 1896, 99 apples were put in storage at the Station. The average life extended to October 6 and the last fruits went out November 14, indicating September as the commercial season for this variety.

Gravenstein. A fall and early winter apple, inferior in keeping quality to Hubbardston. But taking it in its class it stands up well in good dry cold storage.

August 31, 1896, 104 apples were put in storage at the Station. The average life extended to December 6. The last apples went out April 6. There was a high rate of loss up to the first week in December, a low rate of loss from that time till the first week in February after which the loss again became high. Commercial season September to November. A considerable percentage of the fruit remains sound much later than this but such fruit loses very much of its original flavor, quality and bright color.

In the Department cold storage tests No. 1, highly-colored fruit from this Station, stored September 27, reached its commercial limit December 1, after which it softened but showed no scald.

Storage men report its season as extending in cellar storage to October or to December and in chemical storage variously until November or February. It is said to stand heat before going into storage as well as any variety of its season but cars should be iced. Some say it goes down gradually, some say quickly.

Greasy Pippin (see Lowell).

Greening (see Rhode Island *Greening*).

Green Newtown (*Green Newtown Pippin, Newtown Pippin*). A late keeper, coming into its prime in March.

In the Station tests apples of the crops of 1896 and '97 were stored. The mean dates were October 21 for storing; June 1 for average life; and July 28 when the last fruit went out. The results were quite uniform for both tests. There was no loss till toward spring and the rate of loss did not rise very high before May. On the first of May there remained 65 per cent. of sound fruit in one case and in the other over 75 per cent.

In the Department cold storage tests, No. 1 fruit from this Station, stored October 21, was too green for use in March; May 1 it was still hard and free from decay but slightly scalded.

Storage men doubtless sometimes fail to distinguish between this and the Yellow Newtown for they report its season in cellar storage as extending variously until December or February and in chemical cold storage until March or April. The true Green Newtown keeps longer than the Yellow Newtown. It is reported to stand heat well before going into storage and to go down gradually with liability to scald.

GREENVILLE (*Downing Winter Maiden Blush*). At the Station, apples from the crops of 1885, '96 and '97 were tested. The average number under test was 78. The mean dates were October 3 for storing; for average life February 19; and for discarding last fruit May 19. There is a moderate rate of loss through the early part of the winter. About the first of February the rate of loss begins to increase quite rapidly. Apparently the commercial limit is January.

In the Department cold storage tests, large, finely colored, No. 1 fruit from this Station, stored October 21, was in excellent commercial condition till February 1 when scald began to develop. The fruit was one-third scalded March 14.

GRIMES (*Grimes Golden*). Ranks about with Hubbardston as a keeper.

At the Station apples from the crops of 1895, '96 and '97 were stored. The average number tested was 80. The mean dates were October 6 for storing; February 23 for average life; and May 25 when the last fruit went out. The rate of loss was high in November, low in December and January and high through the remainder of the season, except that the crop of '97 showed only a very low rate of loss before the first of February. Commercial season extends to December or January.

In the Department tests, No. 1, fairly well-colored fruit from this Station, stored October 11, was in good condition commercially till February 1, when scald began to develop. May 1, all the fruit was scalded but was still semifirm.

Storage men report its season in cellar storage as extending variously to November or January and in chemical storage to January or February. The fruit should be kept cool before going into storage. In deteriorating it is liable to scald, lose in quality, color and firmness and according to Newhall, to shrivel and become mealy. It goes down quickly.

HAAS (*Fall Queen*). This variety should not go into storage ordinarily.

At the Station fruit of all four crops was tested. The average number put under test was 86. The mean dates were September 27 for storing; December 16 for average life; and March 15 when the last apples went out. The results were pretty uniform, showing that the commercial limit is November or possibly in some seasons December.

In the Department cold storage tests fairly well-colored, No. 1 fruit from this Station was stored September 27. After December 1 the flesh began to mellow, grow mealy and decay.

Storage men report its season as extending in cellar storage to November or December and in chemical storage to January 15. It does not stand heat well before going into storage and the cars should be iced. It goes down gradually.

HASKELL (*Haskell Sweet*). In the Station tests September 21, 1895, 49 apples and September 8, 1896, 105 apples were stored. The average life extended to November 28. The mean date for throwing out the last fruit was February 21. The results were uniform for both tests and indicate that the commercial limit is early November for this variety.

In the Department cold storage tests the commercial limit of No. 1 fruit from this Station, stored October 21, was January 15, after which the fruit began to soften. There was no scald.

HEIDORN. In the Station tests 30 apples were stored September 30, 1897. The average life extended to December 5. The last fruit went out January 12.

HENDRICK (*Hendrick Sweet; Bailey Sweet* incorrectly). Storage men report the season of this variety as extending in cellar storage to April 1, and in chemical cold storage to May 15. It stands heat well before going into storage and goes down gradually, becoming mealy and bursting.

HENNIKER (*Lady Henniker*). In the Station tests 104 apples were stored September 16, 1896. The average life extended to January 28. The last fruit went out June 8.

In the Department cold storage tests well-colored, No. 1 fruit from this Station was stored September 27. After December 1 the flesh began to mellow. There was no scald.

HOLLAND PIPPIN (of Downing and of Eastern New York; *Fall Pippin* incorrectly).

Resembles Fall Pippin closely but begins to ripen earlier. Season in cellar storage according to storage men extends to December 1 and in chemical cold storage to December 15. It does not stand heat at all well, and goes down quickly after becoming mealy and bursting. It varies greatly in keeping quality in different seasons some years keeping well until late. The crop also ripens unevenly. Some of the apples ripen early and are correspondingly short lived while others ripen later and keep correspondingly later.

HOLLAND WINTER. (*Holland Pippin* of Hogg, Langley and Miller, and of Western New York. Not the *Holland Pippin* of Downing and Eastern New York, which is a fall apple.) This is much less liable to scald than is Rhode Island *Greening* and some other varieties of green apples.

In the Station tests fruit was stored in 1895 and '97. The mean dates were October 6 for storing; April 5 for average life; and May 26 when the last fruit went out. The rate of loss was low through the fall and winter but after the first of March it rose rapidly and remained high till the close of the season. The results of both tests were similar, and indicate that the commercial limit for this variety is February or possible early March.

In the Department cold storage tests large, well-colored, No. 1 fruit from this Station was stored October 21. After February 1 the fruit began to soften. There was no scald till long after its commercial season.

HUBBARDSTON (*Hubbardston Nonsuch, Nonsuch, American Blush, Orleans*). Many consider Hubbardston, American Blush and Orleans to be identical varieties while others hold that they are distinct. But Hart has fruited an American Blush which is distinct from Hubbardston. See note on American Blush. Hubbardston is one of the most variable varieties of apples.

It is a very uncertain keeper and should go out early. Morgan remarks that it is thick-skinned and as such would be expected to keep well, but it does not.

In the Station tests fruit was stored in 1896, '97 and '98. The mean dates were October 2 for storing; March 3 for average life; and June 9 when last fruit went out. The rate of loss was comparatively low till the first of January after which it increased rapidly and remained high. Although at the first of March a considerable percentage of the fruit remained sound it had lost much of its original high flavor and quality. The results of the tests were pretty uniform indicating that the commercial limit of this variety is December or possibly early January.

In the Department cold storage tests small, hard, immature fruit, stored October 11, was in prime condition May 1. The results of this test were exceptional. This variety from five other localities, including two in this State, was also tested, but in no other case did it keep nearly so well.

According to storage men the season of this variety extends in cellar storage to December and in chemical cold storage to January. It is not so much affected by heat as some varieties but should nevertheless be kept cool. It goes down quickly. A majority of our correspondents report variously that the inside of the fruit becomes discolored before final decay, that it loses in color and firmness, shrivels, becomes mealy and bursts. But experiences differ greatly on these points, that of Graham especially being unlike the majority of the others. Howes reports that if the fruit is of good color it does not vary much in keeping quality, taken one season with another; but some seasons it is off color and such seasons it soon deteriorates. But Morgan remarks that highly-colored specimens go down quicker than those not so highly colored. Wilson says the keeping quality of this variety depends more on size than on color. If there is only a medium crop on the tree the fruit is large and goes down quicker than if the crop is heavy and the individual fruits smaller and firmer.

Wilson also believes that this variety should not be picked and put into the barrel at once. The fruit should first lay on straw on the ground for two or three weeks to color.

HUNTSMAN. Holds in cold storage well, season until February 1.

HURLBUT. Fruit was stored in 1896, '97 and '98. The mean dates were September 30 for storing; February 3 for average life; and April 4 for discarding last fruit. The results were quite variable with the different tests. The crop of '98 showed a rather low rate of loss till after the first of April when the fruit began to go down very rapidly. The crop of 1897 went down at a rapid rate from the time it was put into storage. Two-thirds of it went out before the first of December. The crop of '96 showed a pretty high rate of loss before the first of December, a low rate through December and January and a high rate again in February and succeeding months.

In the Department cold storage tests hard fruit, not well-colored, stored September 27, was firm till April 1, after which it softened.

HYDE KING (*Hyde's King of the West, Chase, Western Beauty* of our previous records and of U. S. Dept. Agr., B. P. I. Bull. 48.) Apparently well adapted for holding in cold storage.

In the Station tests 66 apples were stored October 17, 1896, and 102 apples October 15, 1897. The mean dates were May 4 for average life, and July 28 when last fruit went out. The year 1896 was decidedly unfavorable to the development of good keeping quality in apples. For the crop of 1896 the average life extended only till March 22, but for that of 1897 it extended to June 15. Ordinarily the fruit may be expected to keep till March or later.

In the Department cold storage tests this variety from this Station, stored October 21, was firm and free from rot or scald May 1.

JACOBS SWEET. Not a good keeper. It is said to crack and rot on the tree as well as in storage.

In the Station tests fruit was stored in 1895, '96 and '97. The mean dates were October 7 for storing; February 12 for average life; and June 30 when the last fruit went out. All crops showed a pretty high rate of loss through the fall and early winter indicating that the commercial limit for this variety is November and December, although a considerable percentage of the fruit may remain sound till February or later.

In the Department cold storage tests green, No. 1 fruit stored September 27, 1901, remained firm till March 1, and in good condition in boxes till April 1; no scald. The crop of 1902 began to mellow February 1, but held in god condition in boxes till April 1. mellow February 1, but held in good condition in boxes till April 1.

Storage men report its season in cellar storage as extending variously to October to December and in chemical cold storage variously to January or March. It does not stand heat well and goes down quickly after having lost in firmness.

Janet (see RALLS).

JEFFERIS. In the Station tests 104 apples were stored October 13, 1896. The average life extended to January 18 and the last fruit went out February 9. The rate of loss was low in October but high in November and later, indicating that October is the commercial limit for this variety.

Jenniton (see RALLS).

JERSEY SWEET. At the Station fruit was stored in 1895, '96 and '97. The mean dates were September 23 for storing; November 19 for average life; and January 18 when the last fruit went out. The results of the tests were pretty uniform and indicate that this variety should not be handled commercially later than September or possibly early October.

JEWETT *Red* (*Jewett Fine Red, Nodhead*). In the Station tests 104 apples were stored September 29, 1896. The average life extended to January 29 and the last fruit went out May 4. The rate of loss was high in November and early December, rather low from then to the middle of March when it again became high. Our experience with this variety leads us to look upon it as a late fall and early winter sort when grown here. For this locality the commercial limit appears to be October or November.

JONATHAN. This variety does not attain to its greatest size in New York State. Its season is about the same as that of Tompkins King.

In the Station tests fruit was stored in 1895, '96 and '97. The mean dates were October 8 for storing; April 6 for average life;

and August 1 when last fruit was discarded. The crops of '95 and '96 showed a moderate rate of loss in November and December, while that of '97 showed but little loss in November and none in December. In each test a large percentage of the fruit kept till March or later but after the first of January the skin began to show dark spots which detracted much from the commercial value of the fruit. On this account the commercial limit appears to be December or early January.

In the Department cold storage tests small, hard fruit from this Station, stored October 27, was in prime commercial condition May 1, hard and free from rot.

Storage men report the season of this variety in cellar storage as extending to December or January and in chemical cold storage variously to January or March. In deteriorating the fruit is reported to shrivel and to go down gradually.

JONATHAN BULER (*Buler*). In the Station tests 106 apples were stored October 8, 1897. The average life extended to February 24 and the last fruit went out May 6.

In the Department tests the commercial limit of this variety from this Station was found to be February 1 in cold storage. After this date the fruit scalded badly but remained firm until April 1.

JONES (*Jones Seedling*). In the Station tests 62 specimens were stored October 16, 1896. The average life extended to May 18 and the last fruit was discarded July 12. The rate of loss was low from January to May, after which it became high.

Juicy Krimtartar (see KRIMTARTAR).

KALKIDON (*Khalkidonskoe*). In the Station tests 45 apples were stored September 28, 1896. The average life extended to February 4 and the last fruit went out May 25. There was a gradual loss of fruit from early in November till the first of March, after which the loss became high.

KANSAS GREENING. In the Station tests 106 specimens were stored October 17, 1896. The average life extended to April 2 and the last fruit was discarded June 30. The rate of loss was low from the first of November till the middle of January after which the fruit went out rapidly.

KANSAS KEEPER. In the Station tests, fruit was stored in 1896 and '97. The mean dates were October 10 for storing; May 1 for average life; and July 15 when the last fruit went out. The fruit kept well till about the first of February, after which there was a moderate rate of loss till May and then the remaining fruit went out rapidly. Commercial limit appears to be February or March.

In the Department cold storage tests, very hard, immature fruit. stored October 21, was still hard and free from scald or decay June 1.

KESWICK (*Keswick Codlin*). This is a fall variety and should not go into storage.

In the Station tests, fruit was stored in 1895 and '96. The mean dates were September 6 for storing; October 22 for average life; and November 19 for discarding the last fruit. The results are quite similar for the two tests, indicating September and early October as the commercial limit for this variety.

Storage men report its season in cellar storage as August and September and in chemical cold storage until November. It does not stand heat well and goes down quickly.

Khalkidonskoe (see KALKIDON).

King of Tompkins County (see TOMPKINS KING).

KIRTLAND. In the Station tests 105 specimens were stored October 13, 1897. The average life extended to May 23 and the last fruit was discarded August 12. The rate of loss in December is low, increasing gradually to a moderate rate in May after which it is rapid.

In the Department cold storage tests, dark red, No. 1 fruit from this Station, stored October 21, was in prime commercial condition throughout the storage season; no scald or decay.

KITTAGESKEE. In the Station tests, fruit was stored in 1895, '96 and '97. The mean date for storing was October 6; for average life April 14; and for going out July 12. The rate of loss is low or moderate up to the middle of May, after which it is high.

KRIMTARTAR (*Juicy Krimtartar*). In the Station tests 103 apples were stored September 13, 1897. The average life extended to November 26 and the last fruit went out April 4. About 60 per ct. of the fruit went out in October and 23 per ct. in November. The commercial season appears to be September, although a few specimens may keep through the winter.

LADY (*Christmas Apple*). While this variety is a late keeper it is usually sold at the Christmas season, and seldom held late, as there is little call for it after the holidays. It stands heat well before going into storage.

Lady Henniker (see HENNIKER).

LADY SWEET (*Pommeroy, Lady's Sweeting*). Ranks hardly with Baldwin as a keeper.

In the Station tests, 29 specimens were stored October 17, 1898. The average life extended to April 30 and the last fruit went out June 12.

In the Department cold storage tests, hard, half-green, immature fruit from this Station, stored October 27, remained hard and sound throughout the storage season.

Storage men report its season as extending in cellar storage to March or April, and in chemical cold storage to May or June. It stands heat well before going into storage and goes down gradually, sometimes after having become soft or shriveled.

LANKFORD (*Langford, Bickers*). This variety is one of the worst varieties to scald after mid-winter.

In the Station tests fruit was stored in 1895, '96 and '97. The mean dates were for storing October 17; for average life April 22; and for discarding of last fruit July 15. The rate of loss through the fall and winter is usually low, increasing in March and becoming high in May.

In the Department cold storage tests medium sized, very hard, half-colored fruit from this Station was stored October 21. It began scalding in January but remained hard through the storage season.

LANDSBERG (*Landsberger Reinette*). In the Station tests 51 apples were stored September 25, 1895, and 105 apples October 16, 1897. The mean date for storing was October 6; for average life February 23; and for discarding the last fruit July 21. The loss was rather high in November, moderate through the winter and high again from about March 1 till the close of the season.

In the Department cold storage tests bright No. 1 fruit from this Station, stored October 21, reached its commercial limit January 15, after which the flesh mellowed; no scald.

LARGE LADY. In the Station tests 105 apples were stored October 3, 1898. Average life extended to May 10 and the last fruit went out July 5. During the fall and winter the loss varied from low to moderate. It became high early in May and continued so till the close of the season. The fruit kept till the first of May with but comparatively little loss.

Lawver (*Delaware Red Winter*). In the Station tests fruit was stored in 1895, '96 and '97. Average number stored 73. The mean date for storing was October 13; for average life May 4; and for discarding the last fruit July 25. The rate of loss was low till May 1, after which the fruit went out gradually in one case and in the other two tests pretty rapidly. Commercial limit of the variety appears to be March or possibly April.

Storage men give the season of this variety as extending to February or March in cellar storage and to April in chemical cold storage. It stands heat well before going into storage and goes down gradually.

Limbertwig. Season in cellar storage until February and in chemical cold storage until May (Newhall) or July 1 (Graham). It stands heat well before going into storage and goes down gradually.

Longfield. In the Station tests fruit was stored in 1895, '96 and '97. The average number stored was 89. The mean date for storing was September 24; for average life November 30; and for going out February 15. The results of the different tests are pretty uniform, showing a high percentage of loss throughout the fall and in fact till the close of the season. The variety does not appear well adapted for holding outside of cold storage. Commercial season September or possibly later.

In the Department cold storage tests clear, well-colored, No. 1 fruit from this Station, stored October 21, in semifirm condition, reached its commercial limit December 1, after which its flesh grew mealy.

Longworth (*Longworth Red Winter*). In the Station tests 103 apples were stored October 2, 1896, and 65 apples October 16, 1897. The mean date for storing was October 9; for average life December 14; and for going out February 9. The results were not uniform. In 1896, 90 per ct. of the crop was gone by the last of December but in 1897 the rate of loss was moderate up to the middle of January, after which the fruit went down very rapidly. Our experience with the variety leads us to regard the limit of its season at Geneva as November for commercial purposes.

LOWELL (*Greasy Pippin, Tallow Pippin*). In the Department cold storage tests, No. 1 fruit, stored September 3, reached its commercial limit October 15, after which it softened and lost quality.

MCINTOSH (*McIntosh Red*). This variety is rather earlier than Hubbardston. Its keeping quality is unfavorably affected by the fact that it ripens its fruit very unevenly. Two or three pickings should be made.

At the Station, fruit was stored in 1895, '96 and '97. The mean date for storing was October 1; for average life January 30; and for going out May 12. The results were quite uniform. They showed a high rate of loss from November throughout the season. It cannot be expected to keep much later than October in ordinary storage without considerable loss.

In the Department cold storage tests, well-colored, No. 1 fruit from this Station, stored October 21, 1901, remained firm till January 15 and in good condition in the boxes till March 1. In 1902-3 the fruit was firm a month longer.

Cold storage men report its season as extending in cellar storage until November and in chemical cold storage until December or January. It does not stand heat well before going into storage and shrivels like Westfield *Seek-no-further*.

MCMAHON (*McMahon White*). This variety ripens unevenly. Fruit was stored at the Station in 1895, '96 and '97. The mean date for storing was September 19; for average life January 19; and for discarding of last fruit April 21. The rate of loss was high from early in October throughout the season. It does not appear well adapted for common storage.

In the Department cold storage tests, No. 1, unevenly-colored fruit from this Station was stored October 21 and reached its commercial limit December 1.

MAGOG (*Magog Red Streak*). September 30, 1896, 51 apples, and October 11, 1897, 78 apples were stored for testing at the Station. The mean date for storing was October 6; for average life January 7; and for discarding last fruit April 14. The results were not uniform in the two tests. In 1896 a large percentage of fruit went out in November and after that the apples went down slowly; but in 1897 the apples began to go down in October, and the loss continued at a rather high rate till the close of the season. The commercial limit appears to be October. Ordinary season for family use October to January or possibly later.

In the Department cold storage tests, No. 1 fruit from this Station was stored September 27 and reached its commercial limit January 15, after which the flesh softened; no scald.

MAIDEN BLUSH (*Lady Blush*). Fruit of all four seasons was tested at the Station. The mean date for storing was September 20; for average life February 20; and for going out May 3. The results were pretty uniform in that the loss was light through the fall but in December it began to increase and continued at a rather high rate till the fruit was gone. The commercial limit appears to be November or early December. Later than this, although the fruit may appear sound, it is deficient in quality.

In the Department cold storage tests, well-colored, No. 1 fruit from this Station was stored October 21. After December 15 the flesh softened; no scald.

Storage men report its season as extending to October in cellar storage and to November or December in chemical cold storage. It does not stand heat well before going into storage and cars should be iced. It goes down quickly. Newhall reports that in deteriorating it scalds, loses quality, color and firmness, softens, becomes mealy and bursts, while Howes and Graham report that it does none of these things. Prisch also remarks that it scalds very easily. Howes remarks that it varies greatly in time of maturing in different seasons and that the earlier it matures the less satisfactory it is as a keeper. Morgan remarks that this variety is peculiar in its manner of scalding in that one-half of the apple turns almost black.

Mammoth Blacktwig (see ARKANSAS or PARAGON).

MANCHESTER. In the Department cold storage tests small, hard, very immature fruit from this Station, stored September 27, was still hard and immature May 1, and free from scald and rot.

MANN. This is one of the late keeping varieties, ranking about with Ben Davis in season.

In the Station tests 97 specimens were put in storage October 18, 1895. The average life extended to April 6; and the last fruit was discarded July 24. From November to April the rate of loss was moderate; after that it was high, indicating that the commercial limit is March or April for this variety.

In the Department cold storage tests small, hard, grassy green fruit from this Station, stored October 11, was still hard and green and free from rot or scald May 1. In a test of this variety at the same time from W. T. Mann, Niagara county, fruit grown on clay soil was greener and less attractive at the end of the season than fruit grown on sandy soil.

Cold storage men report the season of this variety as extending in cellar storage to February or March and in chemical cold storage to March or May. According to Hart it stands heat about like the average variety, but Shuttleworth says it is one of the best in this respect. It goes down gradually, scalding somewhat.

Manwaring. In the Department cold storage tests, No 1 fruit from this Station, stored October 1, reached its commercial limit January 15, after which it decayed badly.

Marigold. At the Station 54 apples were put in storage October 13, 1897. The average life extended to March 6 and the last fruit was discarded June 11. The rate of loss was rather high in November and became high again in January, indicating November or December as the commercial limit for this variety.

In the department cold storage tests, immature small fruit from this Station, stored October 11, was still very hard and free from decay but slightly scalded May 1.

May Seek-no-farther (*Big Romanite* of some). An old variety not now generally cultivated. Season in cellar storage, according to Graham, until March 1, and in chemical storage May 1. It goes down gradually and does not scald badly but the skin becomes slightly bitter.

Melon (*Norton Melon*). Fruit was stored in 1896 and '97 at the Station. The mean date for storing was October 5; for average life March 13; and June 21 when last fruit went out. The results are not uniform for the two tests. In 1896 nearly 50 per ct. of the fruit had gone by the last of December; the remaining fruit went out at a uniformly moderate rate. The crop of 1897 kept till the first of February with only 12 per ct. of loss, after which the rate of loss was uniform and moderately high until June. Ordinary limit of season December or January. Later than this the fruit deteriorates in quality even though apparently perfect.

In the Department cold storage tests, hard, green fruit from this Station, stored October 21, 1901, was still hard and green and free from scald or rot May 1, 1902. In 1902-3 the fruit softened after February 1 and decayed considerably.

MENAGERE. In the Station tests 32 specimens were stored September 17, 1896. The average life extended till April 4 and the last fruit went out July 12. Deterioration proceeded at a uniformly low rate from November to the close of the season.

MILDEN (*Milding*). October 1, 1895, 26 apples and October 12, 1897, 106 apples were stored at the Station. The mean date for storing was October 7; for average life March 4; and for discarding the last fruit May 25. The results of the two tests are pretty uniform. The loss of fruit started at a moderate rate in November and continued at an increasing rate till the close of the season.

MILLIGEN. September 30, 1896, 103 apples and October 12, 1897, 104 apples were stored at the Station. The mean date for storing was October 6; for average life February 16; and for discarding of last fruits June 21. The results of both tests are pretty uniform in showing a rather high rate of loss beginning in November and continuing till the close of the season, indicating that the commercial limit for this variety is October.

In the Department cold storage tests firm, No. 1 fruit from this Station, stored October 11, appeared scalded after January 15, though the fruit was firm and only slightly scalded until March 15.

MINKLER. This variety does not hold perhaps quite so well as Baldwin in storage but is nevertheless a late keeper.

Various storage men report its season as extending in cellar storage to November or to January and in chemical cold storage to December or May. It stands heat well before going into storage and goes down rather gradually, scalding as it does so and losing in quality, color and firmness and the skin becoming bitter.

MISSOURI *Pippin*. Ranks with Baldwin as a keeper. Season in cellar storage till December (Newhall) or April 1 (Graham) and in chemical cold storage till April (Newhall) or July 1 (Graham). It stands heat well before going into storage and goes down gradually. It scalds and softens according to Newhall but not so according to Graham.

MONMOUTH (*Monmouth Pippin*). This variety was tested in all four seasons at the Station. The average number of fruits stored was 84. The mean date for storing was October 18; for average life March 22; and for discarding the last fruit July 14. The results were not uniform as to the rate of deterioration in early winter. The crops of 1895, '96 and '98 showed a rather high percentage of loss before the first of January, whereas the crop of '97 did not show much loss before March. The records indicate that the commercial limit for the variety as grown here is usually November.

In the Department cold storage tests bright, green, No. 1 fruit, stored October 21, was in prime commercial condition May 1, firm and free from rot or scald. Commercial limit in this test about June 1.

MOON. In the Station tests October 2, 1896, 107 apples and October 8, 1897, 50 apples were stored. The mean date for the average life was March 22 and discarding of last fruits June 30. The results of the two tests agree in showing a pretty high percentage of loss in November and a low rate of loss through the latter part of December and the fore part of January, after which the fruit went out rather rapidly. On account of the loss of fruit early in the season this appears to be an unsatisfactory variety for storing, notwithstanding the fact that a considerable percentage of the fruit may keep in good condition till February or later.

MOORE SWEET. At the Station fruit from the crops of 1896 and '97 was tested. The average number of fruits stored was 60. The mean date of storing was October 15; of average life April 21; and of deterioration of last fruits July 11. The figures for the two seasons are fairly uniform and indicate that the commercial limit of this variety is April. Deterioration was very gradual throughout the winter.

In the Department cold storage tests No. 1, immature fruit from this Station, stored October 21, was firm and free from decay or scald till April 15, after which it softened.

MOTHER. At the Station, fruit from the crops of 1896, '97 and '98 was tested. The average number of fruits stored was 86. The mean date of storing was September 18; of average life January 24; and of deterioration of last fruits June 11. The results of the different seasons were quite variable. Deterioration proceeded very rapidly the first part of the season, 40 per ct. or more of the fruit going down by December 10. Later the fruit was deficient in quality although it went down very gradually through the winter. These results indicate that this variety is poorly adapted for holding in storage. Commercial limit, November.

In the Department cold storage tests firm, poorly-colored, No. 1 fruit from this Station, stored September 27, was firm till March 15 and semifirm and in good condition in boxes till May 1; no decay or scald.

Munson (*Munson Sweet*). In the Department cold storage tests fair colored, No. 1 fruit, stored September 29, was in good condition till January 1, after which it softened; no scald or decay.

Nelson. Fruit of the crops of 1895, '96 and '97 was tested at the Station. The average number of fruits stored was 105. The mean date of storing was October 13; of average life May 31; and of deterioration of last fruits July 2. In 1896 and '97 the fruit was stored in the latter part of October and the average life of the fruit extended both years until about the middle of June; but in 1895 the fruit was stored October 2 and its average life extended only until May 3.

This variety kept with practically no loss until April and very inconsiderable loss until May, after which the fruit went down suddenly. Commercial limit, April or May.

Newman. Station tests were made all four seasons. The average number of fruits stored was 76. The mean date of storing was October 12; of average life May 6; and of going down of last fruits July 10. This variety held well until January, then suffered a low rate of loss till March or April, after which it went down rather rapidly. Commercial limit, March or later.

In the Department tests, No. 1 fruit from this Station, stored October 21, was firm and in prime commercial condition May 1; no decay or scald.

Newtown Spitzenburg. Station tests were made all four seasons. The average number of fruits stored was 90. The mean date of putting the fruit into storage was October 18; of average life April 25; and of decay of last specimens June 8. The fruit kept well till February except that of the crop of 1895 which showed a high rate of loss in December. The results with this exception were pretty uniform indicating that the usual commercial limit here would be February or sometimes March.

NEW WATER. In the Department cold storage tests, No. 1 fruit from this Station, stored October 21, remained firm until January 15, and in good condition till March 1; no decay or scald.

Nodhead (see JEWETT *Red*).

Norton Melon (see MELON).

NORTHERN SPY. "This variety is variable in storage behavior. It is particularly susceptible to decay from blue mold, especially if bruised or delayed in reaching storage. If well-colored, picked, packed, and handled with great care, and stored soon after picking, it may be carried in storage as long as most winter varieties." (Powell and Fulton.)

"If carefully packed will keep about the same length of time as Rhode Island *Greening*. Its thin skin and abundant juice render careful handling absolutely necessary." (Howes.)

This variety was under observation at the Station all four seasons. The mean of the dates of storing was October 22; of the average life February 16; and of the discarding of the last specimens June 8. The results with this variety were variable. There was always some loss of fruit as early as November. Sometimes the rate of loss in November rose pretty high. It was usually high also in December. From January to May the results were more variable, but usually the loss was moderately low in January, after which it increased gradually. Well-developed and well-colored fruit retains its high quality till late in the season.

In the Department cold storage tests, well-colored, No. 1 fruit from this Station, stored October 21, 1901, was firm and in good commercial condition May 1, 1902. Light-colored fruit stored November 15, 1902, was in good condition till March 1, 1903, after which it decayed considerably.

According to storage men its season in cellar extends to November or February (Howes, Hart) or March or April (Payne). Fenton remarks that it can be kept in common cellars by regulating the temperature very carefully until May 1. In chemical cold storage its season is given as until April. It stands heat fairly well but should go into storage as soon as possible after being picked. Some report it as going down gradually, others quickly. The variety in nearly all cases reported as being free from objectionable features preceding decay, but only when the fruit is well-colored. This variety is one of the easiest to be bruised and there is much shrinkage in handling it.

Northwestern *Greening*. Observations were made at the Station on the crops of 1895, '96 and '97. The average number of fruits stored was 103. The mean of the dates of storing was October 7; of average life March 11; and of going out June 29. The results were quite uniform in that there was little or no loss in October, a high rate of loss in November and sometimes in December, a moderate rate through mid-winter and a rate varying from high to very high in the closing weeks of the season. On account of the high rate of loss early in the season and continuous loss later it does not promise to be a very satisfactory variety for ordinary storage, yet it is a late keeper. A large part of the fruit does not reach prime condition before January, and much of it remains sound at the close of winter.

In the Department cold storage tests medium-sized, No. 1 fruit from this Station, stored October 21, was hard and free from scald or decay May 1 and in good commercial condition till June 1, when it began to soften.

Storage men report its season as extending in cellar storage to December and in chemical cold storage to May. It stands heat well before going into storage and goes down gradually with loss of quality.

Oakland (*Oakland Seek-no-further*). In our experience with the fruit grown at this Station its season in cellar storage begins late in November or early in December and continues till mid-winter or later.

In the Department cold storage tests bright, hard, No. 1 fruit from this Station, stored October 21, was firm till March 1, and semifirm and in good condition in boxes till April 15; no decay or scald.

Occident. Trials were made at the Station in 1895, '96 and '97. The average number of fruits stored was 106. The mean dates were October 21 for storing the fruit; April 25 for its average life; and June 29 for going out of last specimens. In 1895 the keeping quality was exceptionally poor for this variety, the average life extending only to March 12; but in the other years the variety maintained its reputation for excellent late keeping qualities, showing but a very low rate of loss before the middle of March. Ordinary commercial limit March or April; season January to May.

Ohio Pippin. In a trial at the Station in 1896 fruits were stored September 2. The average life was December 1 and the last specimen was discarded April 19. Three-fourths of the crop went down by November 15, the rest going out gradually through the winter. Commercial limit probably October, although the season of this variety is October to January.

Olive. Fruit was stored at the Station in 1896 and '97. The mean date of storing was October 9, of average life April 6 and of going out of last fruits June 30. The fruit kept well until midwinter when it suddenly showed considerable deterioration for a short time, after which deterioration proceeded gradually till spring opened. On account of very considerable loss in January and February the safe commercial limit appears to be December; yet much of the fruit remains sound till March or April.

Oldenburg (*Duchess of Oldenburg*). This variety is too early to go into storage. Its season in cellar storage is given by storage men as August and September. Newhall reports that it loses in quality and firmness if stored, shrivels and becomes mealy and bursts. It does not stand heat and goes down quickly.

Ontario. In the Station tests fruit was stored in 1896 and '98. The average number of fruits stored was 98. The mean dates were October 19 for storing, April 26 for average life and July 9 when last fruits went out. There was a difference of nearly two months in the average life of this variety in the two years. In 1896 the fruit kept well until December, after which it went down at an even and moderate rate through the winter. In 1898 it kept well until April 1, the loss being only 9 per ct. up to that time. It maintained but little further loss till May 1, after which the fruit deteriorated rapidly.

In the Department cold storage tests, hard, green, No. 1 fruit, stored October 11, was firm and free from decay or scald March 14, but soft and worthless May 1.

Ornament (*Ornament de Table*). At the Station fruit was stored from the crops of 1896 and '97. The average number of fruits stored was 101. The mean dates were October 10 for storing, March 15 for average life and June 22 when last fruits went out. Results both seasons were very similar. The loss was moderately high though variable from November to March, after which it became high. Commercial limit early winter. Season November to May.

In the Department cold storage tests, small, light-colored fruit from this Station, stored September 27, was firm and free from scald but was slightly decayed May 1.

Ostrakoff. At the Station fruit was stored from the crops of 1896 and '97. The average number of fruits stored was 104. The mean date of storing was September 23, of average life December 22 and of going out of last specimens April 17. But the average life of the crop of 1896 was considerably more than double that of the crop of 1897. Moreover specimens kept until June 30 in 1896, but only until February 2 in 1897, a difference of nearly 4 months. Both seasons considerable decay appeared in October. In 1896 sixty per ct. of the fruit went out by February 1. In 1898 over one-half went out in October. Evidently this variety would be very unsatisfactory in ordinary storage.

Paragon (*Mammoth Blacktwig*). In the Department cold storage tests hard, green, No. 1 fruit from this Station, stored October 21, was firm but badly scalded March 14. May 1 it was nearly all scalded but still firm and free from decay.

Parry White. Fruit of the crops of 1895 and '96 was tested at the Station. The average number of fruits stored was 81. The mean date of storing was September 10, of average life October 25 and of decay of last specimens November 6. Results both seasons were quite similar. The test specimens were all or nearly all spoiled by October 31. Season September and early October.

Peach. At the Station, October 1, 1897, 85 specimens were put in storage. Their average life extended to March 2 and the last specimens were discarded June 30. The rate of loss was rather high in November and December but moderate through the rest of the winter, becoming high again in spring.

Peck *Pleasant*. Fruit from the crops of 1895, '96 and '97 was stored at the Station. The average number of fruits stored was

115. The mean date of storing was October 19, of average life March 26, and of discarding of last specimens July 6. The fruit of 1895 kept poorly. The loss began late in November and continued at a high rate till the close of the season. But the other crops showed but a low rate of loss till March; the fruit then deteriorated more rapidly. In ordinary seasons the commercial limit would be February, but the season of the fruit is October to March.

In the Department cold storage tests, hard and green fruit from this Station, stored October 11, was firm and free from decay, but was slightly scalded May 1.

Storage men report its season in cellar storage as extending to October to January, or according to Howes, to March 1; season in chemical cold storage till April. It is said not to stand heat before going into storage because heat makes it scald. If not affected by scald it goes down gradually. It is very liable to scald and in deteriorating loses in quality but improves in color in holding.

Perry Russet. This variety is not favorably regarded by Newhall for storage purposes. Its season in cellar storage is given as November, in chemical cold storage as March. It does not stand heat before going in and it goes down quickly. In going down it loses in quality and firmness, the skin becomes bitter and the fruit often shrivels and becomes mealy.

Peter. Similar to Wealthy in season as well as in fruit.

Fruit was stored at the Station from the crops of 1895 and '97. The average number of fruits stored was 84. The mean date of storing was September 24, of average life February 10 and of decay of last specimens May 10. This variety was in season about a month longer in 1895 than in 1897. Deterioration set in in October and continued at a pretty high rate through the winter. Commercial season September and October.

Pewaukee. This variety was under test at the Station all four seasons. The average number of fruits stored was 82. The mean date of storing was October 15, of average life February 16 and of decay of last specimens May 10. The average life varied from December 6 in 1895 to April 10 for the crop of 1898, or an extreme variation of 4 months, thus indicating that the keeping qualities vary much in different seasons. Commercial limit for ordinary storage varies with different seasons from November to January or possibly February. Deterioration is often high in November and lower after that till midwinter when it rises again.

In the Department cold storage tests small, hard fruit from this Station, stored October 11, was hard and green and free from rot May 1.

Cold storage men report its season as extending in cellar storage variously to November or March and in chemical cold storage to February or March or May 1.

According to Newhall it does not stand heat well and goes down rather quickly, with which Graham does not agree. It is variously reported as scalding somewhat in going down, losing in quality and firmness, skin becoming bitter and fruit shriveling and becoming mealy.

Pifer (*Pfeifer*). Fruit of the crops of 1896 and '97 was stored at the Station. The average number was 102. The average life in 1896 was May 5 and in 1897, July 10, a difference of over two months. The mean date when the last specimens were discarded was July 28. In 1896 this variety kept with little loss until the middle of April when it went down rapidly, but in 1897 it suffered practically no loss before the first of June.

In the Department cold storage tests hard, green, No. 1 fruit from this Station, stored October 21, was hard and free from scald or decay May 1.

Pippin. This name is attached to many different varieties. When used alone very commonly in Eastern New York it means either the Green Newtown or the Yellow Newtown, but may refer to Fall Pippin or to Holland Winter; but in Western New York it is commonly understood to refer to the Fall Pippin.

Plumb Cider. Inferior in keeping quality to Hubbardston, cold storage men give its season in cellar storage as extending to October, and in chemical cold storage to January. It does not stand heat before going into storage and goes down rather quickly with loss in quality and firmness and sometimes with bursting of the fruit.

Pomme Grise (*French Russet*). Fruit from the crops of 1896 and '97 was stored at the Station. The average number was 103. The mean date of storing was October 20, of average life February 1 and of decay of last specimens March 17. But there was a difference of over two months in the season of the fruit the two years. The 1897 crop kept quite well until February but the 1896 crop began going down rapidly in November and the last specimens went out February 9.

Cold storage men give its season in cellar storage as extending to January and in chemical cold storage to March. It stands heat before going into storage fairly well and goes down rather gradually. In going down it loses in quality in storage and the skin becomes bitter and the fruit becomes decidedly mealy and bursts.

Pommeroy (see Lady Sweet).

Pomona (*Cox Pomona*). Fruit from the crops of 1895, '96 and '97 was tested at the Station. The average number stored was 51. The mean date of storing was September 23, of average life November 10 and of going out of last specimens January 30. The fruits had nearly all spoiled by the middle of November. Commercial limit October.

Pound Sweet of Central and Western New York. (See Pumpkin Sweet.) This fruit is large, globular, green, marbled with yellow and with spots or streaks of whitish scarf skin.

Pound Sweet (*Red Pound Sweet;* not *Pumpkin Sweet*). Fruit of the crops of 1895 and '96 was under observation at this Station. The average number stored was 77. The mean date of storing was September 9, of average life November 5 and of going out of last specimens January 7. Results both seasons were quite similar. Season October. Deterioration set in early and proceeded rapidly.

Pumpkin Russet. Fruit of the crops of 1895 and '96 was tested at the Station. The average number stored was 84. The mean date of storing was September 9, of average life November 18 and of going out of last specimens March 25. The average life of the fruit was almost the same both seasons. Deterioration began in September and by November the fruit was nearly all spoiled. Season September and October.

In the Department cold storage tests, No. 1 fruit from this Station, stored September 27, was a little past commercial condition and commencing to soften January 6.

Pumpkin Sweet (*Lyman Pumpkin Sweet, Pound Sweet* of Central and Western New York).

Fruit was tested at the Station in 1895, '96 and '97. The average number stored was 104. The mean date of storing was September 26, of average life February 7 and of going out of last fruits May 18. This variety differed greatly in the length of its season with different crops. The rate of loss is usually high during the fall and its season closes in December or January, although some years a considerable portion of the fruit may remain sound till midwinter or later.

Storage men give its season in cellar storage as extending to November 30, and in chemical cold storage to February. It stands heat before going into storage only moderately well and goes down rather quickly, losing in quality and firmness, shriveling and becoming mealy and bursting.

RALLS (*Ralls Genet, Gennetting, Janet, Jenniton*). Graham remarks that this is a late keeper, and that it would be a strictly No. 1 commercial apple except for the fact that it cracks and bursts on the tree before picking, a fault which we ourselves have not yet observed.

Fruit from the crops of 1896 and '98 was tested at the Station. The number stored was 96. The mean date of storing was October 20, of average life May 23 and of going out of last specimens July 9. Results for both seasons are almost identical. The fruit kept well until the last of April or early in May when the rate of loss rose gradually, becoming very high in June. Commercial limit April.

According to Newhall its season in cellar storage extends to February and in chemical cold storage to May. It stands heat well before going into storage, and goes down gradually, the skin sometimes becoming bitter and the fruit shriveling, becoming mealy and bursting. This variety is but little grown in New York but as grown here its season is December to May.

RAMBO. Fruit of the crops of 1895, '96 and '97 was under observation at the Station. The average number of fruits stored was 103. The mean date of storing was October 18, of average life March 14 and of discarding last specimens June 13. Results in the different seasons were variable, especially as to rate of loss in late fall and early winter. The loss may be low or high in early November but usually is high in late November and

December, becomes moderate in midwinter, then rises again. Commercial limit November, though some fruit may keep until March.

Storage men report its season as extending in cellar storage to November and in chemical cold storage to February. It does not stand heat well before going into storage and goes down quickly, losing in quality and firmness, shriveling, becoming mealy and bursting.

Rawles Genet (see RALLS).

RED CANADA (*Canada Redstreak, Steele Red Winter, Red Winter*).

Fruit of the crop of 1897, stored October 19, showed an average life of June 9. Several specimens still sound were thrown out August 12 to close the test. The fruit suffered but little loss before the first of March and then the rate of loss did not become high till late in May. Nevertheless after mid-winter it gradually became milder in flavor and lost its characteristic high quality.

In the Department cold storage tests immature, hard, No. 1 fruit from this Station, stored October 21, was firm and free from scald and decay May 1.

Storage men report its season as extending in cellar storage to February and in chemical cold storage to April. It stands heat well before going into storage and goes down gradually.

RED RUSSET. Fruit of the seasons of 1896, '97 and '98 was tested at the Station. The average number stored was 87. The mean date of storing was October 3, of average life March 5 and of going down of last specimens June 5. The results in the different years were fairly uniform and indicate that the commercial limit of this variety is February. The fruit kept well until January or February and the rate of loss usually was not high before March.

Reinette de Caux (see CAUX).

REINETTE PIPPIN. Tests were made at the Station all four seasons. The average number of fruits stored was 104. The mean date of storing was October 3, of average life March 5 and of going down of last specimens June 9. An uncertain keeper in fall and early winter, sometimes holding well till midwinter but more often showing a high rate of loss in November, making early November the common commercial limit for handling this variety, although its season extends from October to March.

In the Department cold storage tests hard, immature, No. 1 fruit from this Station, stored October 11, was firm and free from scald March 14, but was slightly decayed. May 1 it was semifirm and good in quality but considerably decayed. Fruit picked in 1901 reached its commercial limit February 1 and by March 14 was badly scalded and specked with rot.

Rhode Island *Greening*. A standard variety for holding in storage.

Tests were made at the Station all four seasons. The average number of fruits stored was 124. The mean date of storing was October 6, of average life March 26 and of discarding last specimens June 15. The crop of 1895 kept poorly, the loss being low till late November when it became high and so continued till the close of the season except for a short period in midwinter, when it was rather low. Ordinarily the fruit kept well till late November, then suffered moderately high loss for a short period, then the rate of loss again became rather low and continued so till March, after which the fruit went down rapidly. Commercial limit January or early February. Season October to March.

In the Department cold storage tests hard, sound, No. 1 fruit from this Station, stored October 11, 1902, was in good commercial condition till March 15, when it began to discolor and soften. Fruit picked in 1901 gave similar results except that it scalded.

Storage men give its season in cellar storage as till February and in chemical cold storage till April 1. It does not stand heat well before going into storage as this induces scald. If in good condition the fruit goes down in storage gradually, but if affected by any disease, quickly. In going down it scalds badly in storage, loses in quality, turns yellow, becomes mealy, and large specimens are liable to burst. Wilson believes that this variety is commonly picked too early for holding in common storage and that this accounts for the prevalence of scald. But cold storage men hold that it should be picked while it is still quite green, that is, in the last half of September. Thus picked it will carry through until very late in the season without any scald. But such fruit does not have the flavor and quality of fruit that is allowed to become riper on the tree. It is even more essential that this variety be hurried into storage at once than the average variety. To bring the best price Rhode Island *Greenings* must be green in color and free from yellow or any blush.

Ribston (*Ribston Pippin*). Possibly equal to Tompkins King as a keeper. Season according to storage men, in cellar storage till November and in chemical cold storage till February. It stands heat before going into storage fairly well but goes down rather quickly though not dangerously so.

Ridge (*Ridge Pippin*). The account given in Bulletin 248 under this name should be credited to Ribston. Since Bulletin 248 was published it has been discovered that among some fruit dealers the name Ridge Pippin is a trade synonym for Ribston and was so used in the correspondence upon which the statement concerning Ridge Pippin was based. The true Ridge Pippin is a very late keeping apple.

Roman Stem. Reports on this variety differ widely. Graham reports that it keeps well. Season in chemical cold storage till April 15. Newhall reports that it is a poor keeper, with season in chemical cold storage till January and in common storage till November.

Rome (*Rome Beauty*). This is reported to be one of the best keepers grown. According to Graham it scalds if picked too green but if left on the tree until it gets its color it is free from this and other undesirable peculiarities which so often precede decay. This variety, the report continues, will stand hard usage.

Tests were made at the Station all four seasons. The average number of fruits stored was 96. The mean date of storing was October 14, of average life April 27 and of decay of last specimens June 25. Results were quite uniform and indicate March as the commercial limit of this variety. The fruit kept well until May when it went down rapidly.

In the Department cold storage tests, hard, light-colored, No. 1 fruit from this Station, stored November 15, 1902, was firm and sound March 14. Fruit picked in 1901 was in good commercial condition until May 1.

Graham reports its season in chemical cold storage as until July 1, "but we have held it until August 4 in ice storage with practically no shrinkage." According to Newhall this variety ranks between Rhode Island *Greening* and Baldwin in keeping quality, with season in common storage until February, and in chemical cold storage until May. It stands heat well before going into storage, but contrary to Graham's experience, Newhall states that in going down it scalds late, loses in quality, color and firmness, skin becomes bitter and the fruit becomes mealy and bursts.

ROMNA. Tests were made at the Station with fruit from the crops of 1896 and '97. The average number of fruits stored was 67. The mean date of storing was September 5, of average life December 25 and of going down of last specimens February 6. The results both seasons were quite uniform, indicating that the commercial limit of this variety is early October. Deterioration commenced early and proceeded rapidly. The fruit was practically all gone by February 1. Season September to January.

RONK. Fruit from the crops of 1896 and '97 was stored at the Station. The average number of fruits stored was 84. The mean date of storing was October 7, of average life March 26 and of going down of last specimens July 6. January appears to be the commercial limit of this variety. Deterioration proceeded most rapidly in March and April, but otherwise regularly from fall to spring. Season November to March.

ROXBURY (*Roxbury Russet*). As grown in New York this is one of the latest-keeping of all varieties.

Tests were made at the Station all four seasons. The average number of fruits stored was 102. The mean date of storing was October 15, of average life April 26 and of discarding last specimens July 17. The keeping quality of this variety fluctuated widely in different seasons. The fruit of 1895 went down at a rapid rate from November to February while in the other years the fruit commonly showed but a very low rate of loss till March or April, after which it went down rapidly. The ordinary commercial limit is April or May.

In the Department cold storage tests No. 1 fruit from this Station, stored November 15, was firm and free from decay May 1. Storage men give its season in cellar storage as extending to May and in chemical cold storage to July. It is reported to vary less from season to season than do most varieties. It stands heat about as well as any variety before going into storage. It goes down gradually, scalding a little some seasons, losing in quality and firmness if kept too late, shriveling, becoming mealy and bursting. Hoag remarks that this variety holds in better condition if kept rather damp.

ST. LAWRENCE. This variety is too early to go into storage as a rule.

Fruit was stored at the Station in 1895, '96 and '97. The average number of fruits stored was 83. The mean date of storing was September 24, of average life December 24 and of discarding last specimens March 16. This variety fluctuated widely in keeping quality in different seasons. October appears to be its commercial limit. The fruit began going down in October and by January 1 one-third or more was gone.

Storage men report its season in cellar storage as October and in chemical cold storage until December. It does not stand heat well before going into storage and goes down quickly. In going down it is variously reported as scalding, losing in quality and firmness in storage, skin becoming bitter, shriveling, becoming mealy and bursting. Britton remarks that the fruit may not remain on the tree until it becomes well-colored and that unless it is well-colored it fades in the barrel to a gray color, rendering it almost valueless. But Howes remarks that the fruit retains firmness if fully ripe and that the bitterness of the skin is due to the fruit being picked too green.

SALOME. In the Station tests fruit of the crops of 1895, '96 and '97 was stored, the average number of specimens put under test being 94. The mean date of storing was October 19, of average life April 10 and of going down of last fruits July 7. The fruit of 1895 kept poorly and went down at a rather rapid rate from mid-November till the season closed. In the other years the fruit kept well till the last of March, after which the rate of loss gradually increased. Commercial limit March but in exceptional seasons December.

In the Department cold storage tests No. 1 fruit from this Station, stored October 21, was in good condition till April 1, when scald appeared freely. June 1 it was still hard but all scalded.

Storage men give its season in cellar storage as extending to January and in chemical cold storage to May. It stands heat well before going into storage and goes down gradually.

Schodack. In the Station tests 30 apples, stored October 29, 1897, showed an average life of July 18. A number of specimens still in good condition were thrown out August 12 to close the test. Decay began in April but proceeded only slowly until July. Commercial limit appears to be June.

Scott (see Baker).

Scott (*Scott Winter*). In the Station tests fruit from the crops of 1895, '96 and '97 was stored. The average number put under test was 71. The mean date of storing was October 10, of average life March 22 and of discarding last specimens June 30. Results were quite uniform all three seasons and indicated that the season of this variety extends to March.

In the Department cold storage tests No. 1 fruit from this Station, stored October 21, was sound, firm and free from scald May 1 but slightly wilted.

Seek-no-further (see Westfield *Seek-no-further*).

Sharp. Fruit of the crops of 1895, '96 and '97 was under observation at the Station. The average number of apples stored was 65. The mean date of storing was September 29, of average life March 1 and of going out of last specimens June 30. The differences in keeping quality the different seasons were very great. Common commercial limit November, but the crop of 1897 kept well until March.

In the Department cold storage tests small, hard, immature fruit from this Station, stored October 21, was firm until January 15 and semifirm until March 15, after which scald appeared and the fruit softened.

Sherwood Favorite (see Chenango).

Shiawassee (*Shiawassee Beauty*). A fall variety, season in cellar storage September, and in chemical cold storage until December. It stands heat before going into storage poorly and goes down rather quickly.

Small Admirable (see Admirable).

Smith *Cider*. In the Station tests 51 apples were stored October 1, 1895. Their average life was March 3 and the last specimens were thrown out July 24. There was a moderate loss in October but a high rate of loss in November and December. Storage men give its season in cellar storage as extending to March and in chemical cold storage to May. It stands heat well before going into storage and goes down gradually. It scalds badly and in going down loses in quality, color and firmness, skin becomes bitter and the fruit shrivels, becomes mealy and bursts.

Snow (see FAMEUSE).

Spitzenburg (see ESOPUS *Spitzenburg* and NEWTOWN SPITZENBURG).

Spy (see NORTHERN SPY).

STANARD. At the Station fruit was tested in 1896 and in '97. The average number stored was 100. The mean date of storing was October 4, of average life January 19 and of discarding of last specimens April 30. Its season extends to January but the commercial limit appears to be early October.

In the Department cold storage tests highly colored, No. 1 fruit from this Station, stored October 21, 1901, was in good commercial barrel condition till April 1 and semifirm and in good box condition till May 1; no scald or rot. Fruit stored September 27, 1902, was mellow after March 1.

STARK. Observations were made at the Station on fruit from the crops of 1895 and '97. The average number of fruits stored was 110. The mean date of storing was October 9, of average life May 21 and of going out of last specimens August 17. There was considerable difference in the length of the commercial season the two years. Its usual commercial limit is May. The crop of 1895 showed a pretty high loss late in December, otherwise the fruit of both seasons kept till May with but little loss. Season January to June.

In the Department cold storage tests hard, greenish red, No. 1 fruit from this Station, stored October 21, was hard and free from scald or decay June 6 when removed from storage.

Storage men give its season in cellar storage as extending to February and in chemical cold storage to May. It stands heat well before going into storage and goes down gradually. It is reported to improve in color in common storage. In going down it is reported to scald late in the season, lose in quality and sometimes in firmness, the skin to become bitter and the fruit to become mealy and burst.

STAYMAN WINESAP. In the Department cold storage tests medium sized, rather dull-colored, No. 1 fruit from this Station, stored October 21, was in good condition till April 1, when the fruit began to scald. May 1, 65 per ct. of the fruit was scalded, the balance still hard.

Storage men report that this variety holds well in storage but is liable to scald.

STREAKED PIPPIN. Fruit stored in 1897 showed an average life of April 12 the last specimens being thrown out June 30. There was practically no loss till February, after which there was a uniform and moderate loss till the close of the season.

STRODE (*Strode Birmingham*). This is a fall variety which should be handled commercially in September. A few specimens may keep until January.

In the Department cold storage tests small, greenish-yellow fruit from this Station, stored September 27, was in good condition till December 15, after which the skin cracked open while the fruit was still firm.

STUMP. At the Station fruit was stored in 1895 and '96, the average number put under test being 101. The mean date of storing was September 6, of average life November 15 and of going out of last specimens January 27. Results both seasons were very uniform in that the fruit went down very rapidly in October, indicating September or possibly early October as the commercial limit for this variety. Season September to November.

Sugar Barbel (see BARBEL).

SUTTON (*Sutton Beauty*). Tests were made at the Station all four seasons. The average number of fruits stored was 98. The mean date of storing was October 8, of average life March 26 and of decay of last specimens June 13. The fruit usually keeps pretty well till late February or March but it kept poorly in 1895. The loss with that crop became heavy in November and then dropped to a low rate through the winter becoming high again in March. Commercial limit of this variety appears to be February. Season November to March.

In the Department cold storage tests medium-sized, well colored but rather dull No. 1 fruit from this Station, stored October 27, was firm for barrel storage till March 15 and in good condition for box storage till April 15.

Storage men report its season in cellar storage as extending to January, in chemical cold storage to March. It stands heat fairly well before going into storage and goes down gradually.

SWAAR. Fruit was stored at the Station in 1896 and in '97. The average number stored was 106. The mean date of storing was October 16, of average life April 6 and of going out of last specimens June 3. The season differed considerably for the two years but appears to extend to the last of February. It shrivels as it begins to deteriorate. It went down gradually until March one season and until May the other, and then decayed rather suddenly.

In the Department cold storage tests, hard, green, No. 1 fruit from this Station, stored October 21, was firm and free from decay but slightly scalded May 1.

Its season in cellar storage is given as extending to December (Newhall, Hart) or March 1 (Howes), and in chemical cold storage to February or April 15 according to different correspondents. It stands heat fairly well and goes down gradually. It improves in color in storage but the skin becomes bitter.

SWENKER. Fruit of the crop of 1896, stored October 3, showed an average life of March 11, the last specimens going out June 8. They went down gradually. There was a high rate of loss in November, afterwards a low rate till March when it became high again. Commercial limit February. Season December to March.

Tallow Pippin (see LOWELL).

TEXAS (*Pride of Texas*). In 1896, 111 apples and in 1897, 105 apples were tested. The mean date of storing was October 9, of average life May 6 and of discarding last specimens July 28. The fruit of 1897 kept with no loss till April; the rate of loss was then small till late in May, when it became heavy. The crop of 1896 kept poorly for this variety, losing heavily in December and January and again in March. The season of the variety usually extends to May.

In the Department cold storage tests small, hard, green fruit, stored October 21, was firm and free from rot but considerably scalded May 1.

TOBIAS. Fruit of the crop of 1896 showed an average life of December 24, with the last specimens going out April 19. It went down gradually from November through the winter.

TOBIAS PIPPIN. Fruit of the season of 1896 showed an average life of January 5, the last specimens going out June 8. One-half of the specimens went down in November and early December. Commercial limit October or possibly November.

TOLMAN *Sweet.* Tests were made at the Station all four seasons. The average number of fruits stored was 72. The mean date of storing was October 8, of average life March 8 and of discarding of last specimens May 30. This variety differed in keeping quality considerably in the different seasons. The fruit usually went down gradually through the winter, but the crops of 1895 and '98 showed a heavy loss in November and December. Commercial limit December or January. Season December to March.

In the Department cold storage tests small, hard, No. 1 fruit from this Station, stored October 1, was firm and free from decay but slightly scalded May 1.

Storage men report its season as extending in cellar storage to December or January, though Phillips Brothers say to March, and in chemical cold storage to February 1 or April, according to different correspondents. It stands heat before going into storage only fairly well and goes down quickly according to some, gradually according to others. In going down it scalds some, shrivels a little and becomes somewhat mealy but improves in color. This variety requires very careful handling for it shows bruises very readily.

TOMPKINS KING (*King of Tompkins County*). Tests were made at the Station all four seasons. The average number of fruits stored was 98. The mean date of storing was September 28, of average life March 4, and of going out of last specimens June 26. The average life of this variety differed greatly in the different seasons, ranging from December 26 to April 11. There is apt to be considerable loss of fruit in November and sometimes it occurs even as early as October, so that the commercial limit is December or exceptionally January. Season October to January or later.

In the Department cold storage tests small, hard and green fruit from this Station, stored September 27, was green and hard and free from scald or decay May 1.

Storage men give its season in cellar storage as extending to December or January and in chemical cold storage to February.

It is not so much influenced by differences in season as are many varieties. It stands heat before going into storage fairly well and goes down gradually, though Newhall says quickly after deterioration has set in. In going down it scalds, loses in quality and becomes mealy.

TUFTS. Tests were made at the Station with fruit of the crops of 1895, '96 and '97. The average number of fruits stored was 50. The mean date of storing was September 30, of average life December 14 and of discarding of last specimens May 6. The average life varied considerably different seasons. The rate of loss was high in October and November. One-half or more of the specimens had decayed by December 1. Commercial limit October. Season October to January.

In the Department cold storage tests hard, greenish red, No. 1 fruit from this Station, stored September 27, was firm and sound March 14; May 1 it was softening and slightly scalded but not decaying.

Tulpehocken (see FALLAWATER).

TWENTY OUNCE (*Cayuga Red Streak, Wine; Cabashaw* incorrectly). A fall apple which usually should be handled direct to the consumer and not go into storage at all. But Hoag says that when allowed to remain on the tree until it gets its color it holds well in cold storage.

Fruit of the crops of 1895, '96 and '97 was under observation at the Station. The average number of fruits stored was 95. The mean date of storing was September 28, of average life January 20 and of discarding last fruits March 31. The fruit goes down rapidly in October and November. Commercial limit, November.

In the Department cold storage tests, well colored, No. 1 fruit from this Station, stored September 29, 1902, was mellow and commencing to decay January 6. Fruit picked in 1901 kept well till February 1.

Storage men give its season in cellar storage as extending to November. It does not stand heat well and goes down quickly. Howes remarks that it cannot be held so long in those seasons when it does not color well; also that spraying sometimes roughens its thin skin. It holds its color if well colored on the tree, but never colors after picking. Some report that it is liable to lose in quality, to shrivel, to become mealy or to burst while others report just the opposite.

Twenty Ounce Pippin (of some; see Cabashea). There is another variety which is known in some parts of Western New York under the name of Twenty Ounce Pippin the identity of which we have not yet determined. In size and coloring it somewhat resembles a smooth roundish Twenty Ounce, but is less mottled and more striped with red. It is distinct from Twenty Ounce in the flavor and texture of the flesh and in the character of the core. It is reported as a better keeper than Tompkins King.

Vandevere (of Western New York) (see Newtown Spitzenburg).

Vanhoy. The fruit of 1895 and of '96 was tested at the Station. The average number of fruits stored was 89. The mean date of storing was October 17, of average life April 30 and of discarding of last fruits June 14. Both tests gave quite similar results. Season January to May. Commercial limit March. There was practically no loss before midwinter.

In the Department cold storage tests, hard, green, fair, No. 1 fruit from this Station, stored October 21, was firm and free from rot but considerably scalded May 1.

Victoria (*Victoria Sweet.*) Fruit of 1896 and of '97 was tested at this Station. The average number stored was 82. The mean date of storing was October 6, of average life February 3 and of decay of last fruits April 21. Results the two seasons were fairly uniform. The rate of loss was rather high in December and moderate from then till February when it became very high. Season October to January. Commercial limit October.

In the Department cold storage tests well-colored, No. 1 fruit from this Station, stored October 21, was beautifully colored and quite mellow January 10.

Wagener. Fruit of the crops of 1896 and of '98 was tested at the Station, the average number stored being 62. The mean date of storing was October 20, of average life May 5 and of discarding of last fruits June 27. Results both seasons were very similar. The fruit kept well till March, after which the loss was high. Season November to February. Commercial limit December. This is a delicate apple and subject to scald. It loses flavor late in the season through apparently sound.

In the Department cold storage tests hard, well colored, No. 1 fruit from this Station, stored November 15, was firm and free from decay and scald March 14. May 1 it was soft and considerably decayed but free from scald.

Storage men give its season in cellar storage as extending to December and in chemical cold storage to February. It does not stand heat well before going into storage and goes down rather quickly. In going down it is reported to scald, lose in quality, color and firmness and to become mealy and burst. Powell and Fulton remark that this variety, unless highly colored, is one of the worst to scald after midwinter.

Walbridge. At the Station fruit of the crops of 1895, '96 and '97 was under test. The average number of fruits stored was 108. The mean date of storing was October 8, of average life April 15 and of discarding of last specimens June 23. The crop of 1895 kept poorly and showed a high rate of loss, beginning in the latter part of December and continuing till the season closed. In the other years results were more normal and there was but little loss till March, when it became high. Commercial limit February.

In the Department cold storage tests hard, green, fair, No. 1 fruit from this Station was stored October 21. After March 15 the fruit softened and much of it became mealy.

Storage men give its season in cellar storage as February and in chemical cold storage as May. It stands heat well before going into storage and goes down very gradually, scalding and losing in quality, color and firmness. Powell and Fulton remark that this variety often ripens unevenly and becomes mealy and discolored in flesh while the skin is bright in color.

Wallace Howard. Fruit of the crop of 1897 showed an average life of March 27, with the last fruits going out June 11. It showed a low rate of decay from November till March then went down more rapidly. Season November to March or later.

Washington Royal. Fruit of the crops of 1895, '96 and '97 was tested at the Station. The average number of fruits stored was 101. The mean date of storing was October 11, of average life March 26 and of going out of last fruits June 21. The different seasons gave widely different figures for average life, ranging from January 28 to June 5. The fruit went down continuously through the winter from November; but in 1895 at a rapid rate, in 1896 at a moderate rate and in 1897 at a low rate. On account of its variable keeping qualities November is the safe commercial limit for fruit grown here although the season extends to May or June.

In the Department cold storage tests small, hard, green fruit from this Station, stored October 11, was mellow but free from rot or scald April 30. Commercial limit March 1; fruit softens without developing yellow color.

Washington Strawberry. Fruit of the seasons of 1895, '96 and '97 was tested at the Station. The average number stored was 46. The mean date of storing was September 12, of average life December 24 and of going out of last specimens April 12. This variety varied greatly in the length of its season with the different years. The fruit went down rapidly in October and November. Its season may extend to December. Commercial limit October.

In the Department cold storage tests light-colored, No. 1 fruit from this Station, stored October 21, was mellow but free from scald or rot January 10. Commercial limit December 1.

Wealthy. Station tests were made with fruit of 1896 and '98. The average number stored was 71. The mean date of storing was September 18, of average life February 8 and of discarding last fruits May 1. There was a difference of over four months in the average life of the variety in the two seasons. One-half of the fruit went down by December 1. Commercial limit October.

In the Department cold storage tests small, hard and immature fruit, stored September 27, was semifirm and slightly decayed but free from scald March 14.

Storage men give the season of this variety in cellar storage as October and in chemical cold storage January. The variety does not stand heat well before going into storage and goes down rather quickly, losing in quality and firmness, becoming somewhat mealy and occasionally bursting.

Western Beauty (see Hyde King).

Westfield *Seek-no-further*. Ranks about with Baldwin as a keeper. Storage men give its season in chemical cold storage as extending to March. It shrivels badly.

White Doctor. Station tests were made all four seasons. The average number of fruits stored was 88. The mean date of storing was October 12, of average life April 9 and of going out of last fruits June 17. There was an extreme difference of over three months in the average life of the fruit in different seasons. The crop of 1895 kept poorly and began to show high rate of loss by the last of December. On the other hand the crop of 1898 showed practically no loss till May. Season usually December to April. Commercial limit early February.

In the Department cold storage tests small, greenish-yellow fruit from this Station, stored September 27, was semifirm, slightly decayed and all specimens slightly scalded March 14. Commercial limit February 1.

WHITE PIPPIN. Station tests were made all four seasons. The average number of fruits stored was 108. The mean date of storing was October 13, of average life April 1 and of going out of last fruits June 29. There was an extreme difference of four months in its average life in the different seasons. The fruit of 1895 kept very poorly, showing a high rate of loss from October till midwinter but in other years the rate of loss was low or moderate till March or April after which it became high, indicating February as the ordinary commercial limit and November to May as the season for this variety.

In the Department cold storage tests sound, No. 1 fruit from this Station, stored October 11, 1902, was firm and free from scald March 14. Commercial limit April 15. Fruit picked in 1901 softened rapidly and decayed after March 1.

Wine (of some). (See TWENTY OUNCE.)

WINESAP. Fruit of 1895, '96 and '97 was tested at the Station. The average number of fruits was 97. The mean date of storing was October 16, of average life May 24 and of discarding of last fruits July 11. The results for all three seasons were quite similar. In 1897 the loss became moderately high in January, and very high in March. In other years it remained low till May then became very high, indicating April as the ordinary commercial limit and January to June as the season for this variety as grown at Geneva.

In the Department cold storage tests, hard, small, light-colored fruit from this Station, stored October 21, was firm and free from scald or decay March 14. April 30 the fruit was still hard and free from decay, but about 75 per ct. scalded.

Storage men give the season of this variety as extending in cellar storage to February and in chemical cold storage to April. It stands heat well before going into storage and goes down gradually with scalding.

Winter Banana. As grown at this Station the season of this variety in common storage extends from late November or early December till about the first of March, but its safe commercial limit would probably not extend much beyond December.

Storage men give its season in cellar storage as extending to December, and in chemical cold storage to April. It stands heat well before going into storage and goes down gradually, scalding and losing in quality, color and firmness.

Wolf River. Fruit of 1896 and '97 was tested at the Station. The average number of fruits stored was 56. The mean date of storing was September 13, of average life January 25 and of discarding last fruits June 12. The rate of loss is high in November and December, indicating October as the commercial limit and September to December as the season for this variety. Some of the fruit may keep later than this apparently in good condition but it is deficient in quality.

In the Department cold storage tests large, bright, No. 1 fruit from this Station, stored September 27, was in prime commercial condition January 6, and free from rot or scald.

Storage men report that this variety does not stand heat well and goes down quickly.

Yellow Bellflower. Fruit of 1895, '96 and '97 was tested at the Station. The average number of fruits stored was 107. The mean date of storing was October 4, of average life March 7 and of discarding of last fruits June 12. There was a difference of three months in the average life of the variety in different seasons. In 1895 it kept poorly, beginning to decay at a rapid rate as early as October and continuing till the season closed. In the other years it kept well till February or March then began to decay rapidly. Commercial limit January or February. Season November to April.

Storage men report this variety to rank between Rhode Island *Greening* and Baldwin as a keeper. Its season is reported as extending in cellar storage to January and in chemical cold storage to March. It does not stand heat well before going into storage and goes down quickly. Its keeping quality is not so much affected by differences of season as is the case with many varieties. Some report that in going down it scalds, loses in quality and firmness, becomes mealy and bursts, but experiences are contradictory on all these points. It improves in color in storage. This variety must be handled very carefully because it is very easily bruised.

Yellow Forest. Fruit stored in 1895 showed an average life of April 22, with the last fruits going out July 24. There was a moderate rate of loss from November to May, after which the fruit went down more rapidly.

Yellow Newtown (*Albemarle Pippin*). Usually equal to Baldwin as a keeper. Season in cellar storage is reported by storage men as extending to February and in chemical cold storage to April. Graham reports that it stands heat very well before going into storage and that it goes down gradually. But Newhall reports that it does not stand heat well. It appears that this variety is often confused with the Green Newtown but it is not so good a keeper as the Green Newtown.

York Imperial (*Johnson Fine Winter*). At the Station fruits of 1895, '96 and '97 were tested. The average number stored was 95. The mean date of storing was October 18, of average life May 5 and of decay of last fruits July 7. The results all three seasons were quite similar. The rate of loss is low till April or May then rises very rapidly. When it does not scald its commercial limit is March and season January to May as grown at Geneva.

In the Department cold storage tests, medium to small, light-colored, very hard fruit from this Station, stored October 21, 1901, began to scald February 15, 1902, and a month later three-fourths of the fruit was lightly scalded on the green side. The fruit remained firm throughout the season. Commercial limit February 15 to March 15.

Storage men give its season in cellar storage as extending to December and in chemical cold storage to February. It stands heat fairly well before going into storage but goes down rather quickly, scalding, losing in color and the skin becoming bitter.

Zurdel (*White Zurdel*). Fruit stored in 1897 showed an average life of May 30, the last fruits going out July 18. There was no loss still February and no considerable loss till April.

SEED SELECTION ACCORDING TO SPECIFIC GRAVITY.*

V. A. Clark.

SUMMARY.

In this report is described a variation of the method of seed selection by salt solutions. The variation differs from the method as heretofore practiced in its making separates at much shorter intervals, thereby permitting of determining with greater precision the distribution of seeds with regard to specific gravity. With different ranges of specific gravity different cultural properties of the seed are often found to be correlated.

The method of a series of separates differs from the method of samples, which has been principally used heretofore by scientific investigators, in that it distinguishes between individual seeds of different qualities, in so far as these qualities are correlated with specific gravity, and separates them; and does not simply indicate the average specific gravity of the whole lot, as is done by the method of samples.

Seeds of the same lot commonly are distributed through a considerable range of specific gravity. If the seeds are of good quality, the larger part of them are found within a relatively narrow range near but not at the upper limit of specific gravity for the variety. But in the the case of oil-bearing seeds the range of greatest frequency of distribution is intermediate.

Specific gravity may be utilized as a means of separating foreign matter, or, occasionally, foreign seeds, as has long been known to practice.

Within the limits of the variety, the lower the specific gravity, the greater the proportion of small seeds and vice versa. The separation of an unsifted lot of seeds by the method of salt solutions is in reality in part a crude separation according to size, so far as cultural properties are concerned.

*Reprint of Bulletin No. 256.

A quite definite correlation exists between the specific gravity of a seed and its germination. Seeds of low specific gravity do not germinate at all. Those in a range higher germinate scantily and in many cases produce comparatively weak plants. Seeds of highest specific gravity, or in the case of oil-bearing seeds, those of intermediate specific gravity, show the highest percentage of germination.

In occasional species a correlation between the specific gravity of the seed and it's color has been observed.

A few chance observations appear to indicate that there is a correlation between the specific gravity of the seed and its viability. It would appear that seeds of a specific gravity representing the greatest storage of reserve material are longest lived, and that seeds of low specific gravity or of a specific gravity representing a comparatively low storage or reserve material, soonest lose their vitality.

To some extent a correlation appears to exist between the specific gravity of the seed and the vigor of the resulting plant. Results in this case are, however, not so clear cut as they are in the cases of the cultural correlations already mentioned.

Differences in specific gravity are due either to differences in structure or differences in composition. If differences in composition are not obscured by differences in structure, which they often are, the differing specific gravities to which they give rise are indexes to the quality of the seed.

Differences in specific gravity may indicate differences in composition due to different degrees of ripeness. In this case specific gravity is an index to ripeness.

If differences in specific gravity are due to differences in structure, these differences may or may not be correlated with some other cultural property of the seed, and accordingly specific gravity may or may not be an index to quality.

It follows that specific gravity is by no means of unfailing reliability in determining the quality of seeds.

INTRODUCTORY.

The work herewith reported is an outgrowth of an investigation conducted by Prof. S. A. Beach of this Station on seed selection as applied to the breeding of grapes. While weighing individual seeds the writer observed that they were of very unlike specific gravities. This observation suggested a study of the subject of specific gravity as a moment of seed selection.

This report is based on only one season's work. The literature of the subject is reviewed and some preliminary observations are presented. The presentation throughout is tenative and subject to future verification, modification and especially development. It is hoped to continue this work.

I am under obligations to the authorities of Cornell University, and especially to Mr. W. H. Austen, in charge of the Reference Library, for kind permission to use the University Library.

HISTORICAL.

The method of seed selection by means of salt solutions has long been known to gardening. Yokoi* remarks that it has been practiced for over 250 years in China and Japan. A simpler form of the method, which consists in floating off light seed in pure water, is by some practiced in this country at the present time, as for instance among growers of lettuce under glass. But the method appears never to have come into any considerable vogue, either in Europe or in America; and this despite the facts that striking results have repeatedly been obtained by its use and that several European experimenters have recommended it.

Perhaps one reason is that several prominent investigators, including Nobbe, Hellriegel and Wollny, have examined it critically and declared it to be of little or no value in agriculture. Yet over against the critical studies of these trained investigators stands a mass of experience and numerous practical tests which declare that the heavier seeds as separated by salt solutions do produce the better crops. Where there is much smoke there must be some fire. Perhaps the practical experimenters, who did not examine the subject critically, have misinterpreted their results; but the results stand.

PREVIOUS INVESTIGATIONS FAVORABLE TO THE SPECIFIC GRAVITY METHOD.

Some of these practical tests and recommendations may be cited:

*Citations for this and other references in this report to writings on specific gravity of seeds referred to with the name of the author, may be found in bibliography at the close of this bulletin.

Haberlandt separated winter rye at specific gravity 1.30 and oats at 1.03 by means of salt solutions. In both cases the heavier kernels gave considerably the larger yield in quantity and at the same time the quality of the crop was better, since the average weight of the individual kernels from the heavier separates was greater than that from the lighter separates. Furthermore, the lighter seed gave a less proportion of grain to the amount of straw produced than did the heavier seed.

Rümpler recommended the use of solutions of sodium nitrate for separating barley, wheat, rye, etc. He advises planting only the heaviest third of such seeds.

Müller separated barley by salt solutions into light, medium and heavy separates. The heaviest seed gave the largest percentage of germination, the largest average number of internodes per plant, largest yield of grain, the largest total yeild of vegetable matter, the highest average weight of grain per head and the highest average weight per kernel.

Grandeau separated oats by immersing them in water and made culture tests with the two separates. On the basis of equal areas the yield of grain from the heavier separate was 2.09 Kg., and of straw 6.079 Kg. From the lighter separate the yield of grain was 1.83 Kg. and of straw 5.71 Kg. At the market price of oats at the time these crops were harvested, the money value of the crop from the heavier seed was 14 per ct. greater than that from the light seed. In reporting these experiments the author remarks that certain other experimenters have increased the money value of the crop as much as 22 to 25 per ct. by thus separating the seed.

Lyon separated seed, first by using a solution of calcium chloride and later by the use of an ordinary seed fanning mill. One year the yield from the heavy seed was 27.2 bu. as compared with 26.7 bu. from ordinary seed of the same sample and 21.8 bu. from the light seed. Samples of the crops from the heavy and the light seed were again separated and planted the following year. The heavier half from the heavy sample yielded 28.5 bu. as compared with 25.0 bu. from the check, while the lighter half from the light seed yielded only 23.9 bushels.

Kobayashi separated rape seed into lots of different specific gravities by means of salt solutions. He found that seed of medium specific gravity was best for planting. It was also richest in oil.

Seulen recommends floating off light seeds and foreign matter from garden seeds which are to be planted, by immersing them in water. Other persons who have reported favorably on the practice of seed selection according to specific gravity are Church, Dietrich and Trommer, as cited by Wollny.

Especially timely is the present investigation in view of the fact that a well known English seed firm has recently advertised that they are perfecting a method of selecting seeds according to specific gravity. This firm already advertises to apply the method of selection by salt solutions to the selection of forage roots to be used for mothers.

PREVIOUS INVESTIGATIONS NOT FAVORABLE TO THE SPECIFIC GRAVITY METHOD.

Mention will now be made of some of the investigations which have led experimenters to assert that the method of specific gravity is of little or no applicability in practice:

Hellriegel separated from a lot of barley, kernels of specific gravities 1.255, 1.205 and 1.15, all of which weighed from 34 to 36 milligrams each. The experiment was repeated a second season, in this case selecting seeds lying between 36 and 38 milligrams. There was no noticeable difference between the plants from the different seeds and the investigator concludes that specific gravity has no considerable effect on the vigor and size of the plant, either as a seedling or as a mature plant.

Marek re-investigated the method of seed selection according to specific gravity by exact methods. His conclusion is that specific gravity is no general criterion of the quality of the seed, and that only when the more intimate relations of the composition of the seed to its specific gravity are known can the latter be accepted as a standard of judgment of quality.

Nobbe has reviewed the subject and has also reached the conclusion that the practice is of little value in agriculture.

Willard, Clothier and Weber applied the method of specific gravity to the selection of seed corn, but without positive results.

Wollny has critically reviewed the subject and reaches the conclusion that specific gravity is of no account in seed selection.

He remarks further, that previous investigators who have reported favorably on the method have disregarded the absolute weight of the seed and have thereby been led into error.

The method of salt solutions as applied to potato tubers and to roots is not considered in this article. Much experimental work both practical and scientific has, however, been done along these lines in Europe. A critical review of such work is made by Wollny. In this country the late Prof. E. S. Goff* made practical application of the method to the selection of potato tubers and with good results.

METHODS OF DETERMINING SPECIFIC GRAVITY AND OF SEPARATING SEEDS ACCORDING TO IT.

Two fundamentally different methods have been used in studying the specific gravity of seeds. One is the method of separates illustrated in the experiments of Grandeau, Lyon and others. The other is the method of samples, illustrated in the pycnometer method. It will be perceived at once that these two general methods approach the subject from entirely different standpoints. The method of samples is identical in principle with the same method as applied in sampling fertilizers, etc. Its object is not to separate one constituent from another but only to determine the average composition of the whole mass. In the method of separates, however, the object is to distinguish between different individuals or elements. As applied in seed selection the method of separates is historically much the older and has grown up with agricultural practice. The method of samples is of comparatively recent introduction and belongs to the realm of criticism.

THE METHOD OF SEPARATES.

The application of the method of separates has been more or less arbitrary. Most frequently it has been the custom to separate a lot of seeds, irrespective of their intrinsic quality, into two or three lots of generally equal quantities. In so doing the fact that seeds vary much in quality under different conditions and in different seasons, is not taken into consideration and no attempt is made to define with exactness the limits within which seeds of different qualities occur.

*Wis. Agr. Expt. Sta. Rpt., 1895, p. 317.

The objections to the method are mechanical in nature—they are the objections arising from a faulty technique. Seeds generally take up water, though there are very considerable differences between individual seeds of the same lot with regard to the rapidly with which they do so. For this reason the method of salt solutions as commonly applied does not yield separates exactly comparable; but the differences in specific gravity due to unequal absorption of water are at most only a few one hundreths of unity, and for practical purposes may be to a considerable extent disregarded. Another objection which has been urged against the method of salt solutions is that it is slow and troublesome of application; but it is no more so than is that of immersing oats in hot water as a treatment for oat smut. This latter is recognized as an agricultural practice in good standing.

The logical applications of the methods of separates and of samples are fundamentally different. As has already been remarked, the method of separates is suited properly for distinguishing between different individual seeds in the same lot. It is analytical. The method of samples is not analytical, but is appliable in judging the comparative merits of two lots of seeds. It does not take cognizance of individual differences among the seeds; it judges the average value of the whole lot.

THE METHOD OF SAMPLES.

The method of samples has been applied in several ways. A simple and elementary form of it was used by Grandeau. He placed a certain number of seeds in a small graduated cylinder of water and noted the amount of water displaced. From this and the weight of the seeds previously determined the specific gravity could be computed. This method is quick of operation and for this reason is subject only to comparatively small error on account of absorption of water by the seeds.

The method which has been most used in exact investigations in seed selection according to specific gravity is the pycnometer method. This method gives very exact results but is slow of application, even in the laboratory. In gardening practice it is utterly out of the question.

Determinations by this method were at first made in distilled water, but the use of water was soon abandoned for the reason that the seeds were often found to have changed materially in specific gravity before the determination could be completed. Various devices have been tried with a view to preventing this absorption of water, but apparently without entire success, since none of them have become a recognized part of practice. One of these methods, suggested by Wollny, was to oil the hands lightly and to roll the seeds between them before making the determination. In reviewing the literature of the subject the present writer has not noticed that this practice has been continued by any other investigator. The objection to it is, that more or less air is imprisoned and the results vitiated. Another device is to coat the seeds with shellac or varnish. In a series of careful determinations it was found that this treatment of the seeds changed their specific gravity slightly, though not enough presumably to be of importance in practice. Obviously, seeds thus treated would be valueless for use in culture tests.

In order to obviate the practical difficulty involved in the use of water, various other liquids have been employed. Among these are alcohol, naptha, benzine and petroleum. A quite extended study was made by Wolffenstein of the subject of media for use in making pycnometer determinations. He it was who first suggested the use of petroleum. The employment of this medium obtained much currency among investigators. The superiority of this fluid for use in making specific gravity determinations lies in the fact that the seeds take up almost none of it. A very considerable objection to it is, that it changes much in volume and consequently in specific gravity with even small changes in temperature, so much so that corrections must be made for temperature changes so small as one-half degree.

One practical difficulty which experimenters have to contend with, is the adherence of air to the seed when immersed. In order to obivate this difficulty Nowacki, after having put seeds in petroleum in a pycnometer, placed the apparatus under the receiver of an air pump and exhausted the air uniformly to a stated pressure, allowing the apparatus thus to remain for fifteen minutes, after which the determinations were made. In thus treating the seeds a little petroleum was absorbed, but the error therefrom is stated not to be of importance, not amounting to more than three or five per ct. according to Nowacki.

The pycnometer method as commonly applied carries the determination to four places of decimals; but this is an unnecessary refinement of operation, since separates differing by only one-hundredth of unity commonly show very little if any difference in germination and in vigor of seedlings except at or near critical points, as 1.18 for naked leguminous seeds, below which points germination does not take place.

THE METHOD OF A SERIES OF SEPARATES.

Taking into consideration the inadequacy of the method of samples and considering the fact that seeds differ much in composition and other characters according to the conditions under which they are grown, and further, that seeds borne on the same mother plant also differ, it is surprising that greater efforts have not been made to separate these seeds according to their cultural properties. The somewhat primitive separation of a lot of seed into two or three arbitrarily determined separates has already shown that very considerable differences in cultural properties do exist. By making these separates at equal intervals of specific gravity and sufficiently near together, it should be practicable to determine the range within which seeds of different cultural qualities occur, so far as such are in direct correlation with specific gravity. By so doing, prescriptions for the selection of seed according to specific gravity would be made on the basis of an unchanging standard. Heretofore the method used has given variable results as regards quality of seeds, since a stated fraction, as one-half, of a variable quantity—the specific gravity of seeds grown under different conditions—was taken.

The present writer has put this idea into effect by using a series of salt solutions differing each from the next by one one-hundredth of unity in specific gravity. Seeds passed through such a series of solutions are grouped into a series of separates having different ranges with which various properties of great economic importance are found to be somewhat definitely associated.

As will appear later, this method of series takes into consideration the very unlike conditions under which seeds are grown, so far as these differences find expression in the specific gravities of the seeds. It also distinguishes between different individuals in the same lot. For instance, when a lot of seed is harvested some individuals are not quite so ripe as others. These differences find expression, to some extent at least, in specific gravity. In many cases seeds grown on different soils or in different climates are of unequal value for planting. To some extent these differences also find expression in specific gravity. The method of a series of salt solutions theoretically sorts out from a lot of seeds, those best suited for planting, irrespective of the proportion of them in the lot, whether few or many..

It is unnecessary that solutions differ by less than one one-hundredth of unity, as is shown by the following facts: (1) Except at critical points in the range of specific gravity, there is little or no difference in the cultural characters of seeds differing by no more than one one-hundredth of unity. (2) Most seeds take up water rapidly and in the length of time it takes to make a series of experimental separates, some seeds at least will change as much as one one-hundredth in specific gravity and sometimes more. (3) In skimming the seeds from one solution to the next, the solutions are somewhat changed in density and are liable to vary as much as one one-hundredth if they are not frequently tested. In a few cases, however, the author has used solutions differing from each other by only five one-thousandths of unity.

SALTS USED IN MAKING SOLUTIONS.

There are a number of highly soluble salts that may be used in making up these solutions. The present writer has used common kitchen salt (sodium chloride), ammonium nitrate, and sodium nitrate (Chili saltpeter). Common saltpeter (potassium nitrate) and calcium chloride are salts that have been much used. One author has used molasses with good results. Sodium chloride makes up a solution of a maximum density at room temperature in the summer time of 1.20 and will hold up to this density unless a very cool day comes. In winter time this solution will not hold up above 1.175 to 1.185 according to temperature. Hence this solution can only be used for separating seeds of less specific gravity than these densities. For denser seeds some of the other salts must be used. Ammonium nitrate holds up to about 1.31 at room temperature in the summer time and to about

1.28 in the winter time. This solution is comparatively expensive and does not entirely separate the heaviest seeds, some of which are among the most common. Sodium nitrate holds up to about 1.39 in the warmest summer weather and to about 1.36 in the winter time. This solution can be used for completely separating the heaviest seeds, such as Leguminosæ and some of the cereals.

The technique of solutions has not been much studied by the present writer and practically no attempt has been made as yet to use solutions of a density less than that of water. It is suggested however, that petroleum, naptha, benzine, etc., might be adapted to this purpose, if there was occasion for it. As a matter of fact, however, many seeds with a density as low as that of pure water do not germinate anyway and there is no need of carrying the separation below unity. The present writer has grouped all seeds of a specific gravity less than that of water together and indicated them collectively by the sign < 1.00. The sign $>$ is used to indicate "greater than."

DETAILS OF MANIPULATION.

In practice, the solutions were made up in glass jars, determining densities with a common dairy hydrometer. A part of the solution in each jar was poured into a saucer beside it, and the seeds to be separated poured into one of the higher solutions—which must be denser than any of the seeds—and all seeds that floated skimmed over with a piece of wire gause into the solution next lower. In each solution such seeds will settle as are denser than that solution but less dense than the one next above.

In practice much difficulty is found in getting rid of adhering air bubbles. This difficulty can be obviated at least in part by dipping the seeds from water into some solution or into alcohol, formalin or some similar substance and then dipping them quickly back into water.

DETERMINATIONS BY PREVIOUS INVESTIGATORS.

Mention should be made of some of the results obtained by previous investigators of the specific gravity of seeds. Nobbe gives a long table of specific gravities as reported by earlier investigators. Many of these determinations were made by Renz, who simply made up a solution until one-half of the seeds had sunk. Many of his figures agree with the optimum as determined by the present writer; but in some cases our results are widely at variance. For instance, he gives the specific gravity of grape seeds at 1.06, whereas as a matter of fact the optimum for grape seeds, including vinifera varieties, which were what Renz probably used in making his determinations, ranges from about 1.10 to 1.13 or 1.16. In many varieties, especially the stronger growing ones such as Concord, seeds of the specific gravity of 1.06 do not germinate.

Nobbe refers also to determinations by v. Grevenitz and by Hoffman, neither of which are of value. Hänlein has also reported determinations of the specific gravities of thirteen kinds of seeds.

RANGE AND DISTRIBUTION OF SEEDS WITH RESPECT TO SPECIFIC GRAVITY.

The most casual examination of some of the tables given later on in this report (see for instance Tables II and VII) reveals the fact that while the seeds of any kind of plant are distributed through a wide range of specific gravity, most of them are commonly found within a relatively narrow range or within two such ranges. If the seeds are of good quality and high in percentage of germination, most of them are found near but not at the maximum specific gravity. Such distribution is shown in Table VII and Chart II. If, however, the seeds in their fresh condition are low in percentage of germination and are of poor quality, many of them are found at or near the opposite extreme of the series of separates. This fact is brought out in Table II and Chart I, in which is shown the relative distribution of seeds of an imperfectly self-fertile variety of grape close-pollinated.

All the common kinds of farm and garden seeds that the writer has examined show some floaters, that is, seeds that float on pure water. The range of density in different kinds of seeds is very unlike. Within the limits of the same species different varieties show different specific gravities, sometimes quite markedly so. This point is brought out in Table I, showing the distribution of seeds of numerous varieties of grapes.

It may be remarked that the very large number of seeds of low specific gravities, that is of ungerminable seeds, is probably attributable to imperfect pollination. Other cultural conditions also exercise a marked influence on the specific gravity of seeds. For instance, the common field corn of New York State ranges in specific gravity up to about 1.15; but some of the corn of high protein content now being bred in the west ranges up to 1.25. It is a matter of common knowledge that wheat grown in northern Colorado is heavier than the same variety grown in the Mississippi valley. It has also been definitely proven by Wollny that the same variety may vary in specific gravity from year to year. That investigator's determinations were made by the method of samples, and consequently represent only averages for the whole amount of seed. While the optimum specific gravity of a variety grown under favorable conditions might not vary much, numerous conditions might enter in to bring it about that there might be a larger number of slightly inferior seed in one sample than in another. By this consideration the average specific gravity would be lower and yet the optimum specific gravity might remain unchanged. The suppositions are confirmed in the writer's mind by his observation of grape seeds grown under different conditions; but figures are not at hand to support these statements.

As to the range of specific gravity in the seeds of a number of cultivated crops, the Cruciferæ range from about 1.21 down, lettuce from 1.10, Solanaceæ from 1.12, onion from 1.18, carrot from 1.15, grapes from about 1.16, buckwheat from 1.23, and wheat, rye and naked leguminous seeds from 1.30 to 1.36 according to the variety.

Renz concluded from his investigations that the seed of every kind of plant has in its natural ripe and fully developed condition a specific gravity which varies only between certain limits, apparently meaning by this rather narrow limits. From this conclusion he makes the deduction that specific gravity can be used as a distinguishing character of the kind and quality of the seed. The writer's observations tend to support the conclusion that specific gravity is a *character* of the variety but not a *distinguishing* character. This last is for the reason that seeds of nearly related species or varieties overlap each other in the range of greatest frequency of distribution and consequently are not separable by the mechanical means of solutions; also, because the proportion of seeds not of the optimum specific gravity varies greatly under different conditions, and hence the average specific gravity of different samples of the same variety would not be constant.

TABLE 1.—SHOWING THE VERY DIFFERENT DISTRIBUTION OF DIFFERENT VARIETIES OF GRAPES AS REGARDS SPECIFIC GRAVITY WHEN GROWN IN A VARIETY VINEYARD OPEN TO CROSS POLLINATION.

Sp. gr.	Agawam.	Alice.	Aminia.	Arkansas.	August Giant.	Berckmans.
<1.00	10	54	19	3	8	27
1.01	1	6	1		2	4
1.02	2	10	2			8
1.03	1	14	1	1	1	5
1.04	1	19	3	1	3	7
1.05	5	32	14	5	5	7
1.06	2	14	9	2	3	3
1.07	17	25	36	20	38	12
1.08	25	6	31	57	62	
1.09	37	6	45	51	50	
1.10	39	10	27	37	21	
1.11	28	2	10	15	7	
1.12	23	1	2	7		
1.13	9	1		1		
	200	200	200	200	200	73

Sp. gr.	Black Eagle	Brighton.	Brilliant	Canada.	Catawba.	Champion.	Chautauqua.	Clevener.
<1.00	16	33	9	121	22	42	3	2
1.00			1	23		5		1
1.01	1			9			1	
1.02	2			9	1	4	2	
1.03			2	2		2		1
1.04	1		4		1	6		1
1.05	1		12	1	6	12	2	6
1.06			16	1		19		36
1.07	3	3	22	7	2	21	4	50
1.08	4	2	74		2	27	1	15
1.09	2	5	38		8	22	10	1
1.10	5	8	13		6	21	10	
1.11	15	33	8		16	11	12	
1.12	39	45	1		68	6	9	
1.13	2	8			59	2	4	
1.14	94	61			9			
1.15	8	2						
	193	200	200	173	200	200	58	113

Table 1—(*Concluded*).

Sp. gr.	Creveling.	Delaware.	Diamond.	Diana.	Dracut Amber.	Elvibach.	Elvira.	Grein Golden.	Hartford.	Herbert.
< 1.00	1	12	25	51	8	8	74	6	50	39
1.00				11		1	1		1	12
1.01			1	4						14
1.02	1		1	15			1	1	1	14
1.03	2	1		19			1			15
1.04	3	1	1	23	1		1			18
1.05	6		1	21	3		2			19
1.06	2	2	3	9	3		4	1	1	11
1.07		3	7	27	11		19	3	5	23
1.08		9	5	12	17		27	2	6	13
1.09		5	5	5	10	3	36	3	6	3
1.10		18	16	3	32	6	18	1	23	6
1.11		33	19		57	14	14	17	56	1
1.12		36	45		41	52	2	14	32	
1.13		14	34		12	84		18	17	1
1.14		4	31		5	31		40	2	
1.15			4			1		3		
1.16			2					2		
	15	138	200	200	200	200	200	111	200	189

Sp. gr.	Iona.	Isabella Seedling.	Lady Spink.	Lindley.	Lutie.	Marion.	Massasoit.	Matilde.	Black Hamburg.	Poughkeepsie.
< 1.00	26	13	16	9	20	2	15	30	10	126
1.00	3	1			2		3	1	2	7
1.01	1				4			1		
1.02	1			2	4		1	1	1	3
1.03	6				8		11	3	2	2
1.04				1	10		10	2	2	2
1.05	2			7	20		28	6	5	5
1.06	3	1		6	6		34	9	3	11
1.07	11	6		65	16		44	9	3	11
1.08	18	33		48	8		27	29	20	9
1.09	23	46		34	1		17	29	2	15
1.10	19	28		13			6	21	7	10
1.11	52	39	2	11		4	2	25	3	31
1.12	17	2	3	4		26	2	9	1	12
1.13	9		13			49		2		8
1.14	8		72		1	117				4
1.15			3			2				
1.16	1									
	200	169	109	200	100	200	200	177	61	256

Sp. gr.	Regal.	Rochester.	Station 95.	Station 96.	Station 98.	Station 116.	Triumph.	Ulster.	Winchell.	V. riparia.
< 1.00	37	8	11	1	7	3	17	37	4	197
1.00	5	3	2							1
1.01	1	5			1			1		
1.02	3	9				1	2	1		1
1.03		13		1			1	4		
1.04	3	19	1				1	3		
1.05	3	21	2		2		5	3		
1.06	3	23	2				5	7		
1.07	2	43	7	1	3		11	7	4	
1.08	8	25	4	1	2		6	26	1	
1.09	10	21	15		3	1	15	35	1	1
1.10	16	5	19	1	6	1	18	56	1	
1.11	48	4	55	3	6	8	42	54	3	
1.12	22	1	55	6	15	4	33	12	2	
1.13	20		39	4	12	3	21	2	6	
1.14	16		44	35	100	8	19		5	
1.15	3		3	12	36		2			
1.16				8	3					
1.17				3						
	200	200	259	76	196	29	200	248	27	200

DIFFERENCES IN DISTRIBUTION OF DIFFERENT VARIETIES OF GRAPES.

How greatly varieties may vary in average specific gravity, that is in distribution of the seeds according to specific gravity, is abundantly brought out in Table I, in which are shown records of separations of a number of varieties of grape seeds grown under normal conditions in a variety vineyard. For instance, much the larger part of the seeds of Agawam are found in the range from 1.07 upward, which is the range within which alone germination takes place, that is the range within which good seeds are comprised. But in the case of Canada most of the seeds are comprised in the range from 1.03 downward, in which range germination does not take place in this variety. In the case of the particular observations shown in this table, the very great differences in distribution of seeds is probably due in large part to unequal protencies of the pollen which chance to alight on the pistil. That there is ground for this assumption is abundantly proven by examinations of seeds, both cross and self-fertilized, made by the writer for Prof. Beach, and representing some twenty different varieties. In the case of such strongly self-fertile varieties as Concord and Worden it was found that the distribution of the seeds as regards specific gravity was about the same whether the flowers were self-pollinated or cross-pollinated. But in the case of varieties which Prof. Beach has heretofore examined and classed as imperfectly self-fertile, it was found that very striking differences in the distribution of the seeds as regards specific gravity—that is as regards quality—are correlated with the potency of the pollenizing parent. For instance, in the case of Little Blue, an imperfectly self-fertile hybrid, only 30 per ct. of the seeds from self-pollinated bunches were found in the range from 1.07 up; but other bunches from the same vine open to cross-pollination showed 60 per ct. of seeds within the same range. See Table II and Chart I. Even in this latter case there was a very large percentage of poor seed. It is a fair question whether a considerable part of these may not have been due to imperfect pollination from some source. It would be interesting to compare the specific gravity of the seeds of this variety self-pollinated with the seeds of the same variety cross-pollinated with some strongly self-fertile varieties as Concord.

TABLE II.— SHOWING DISTRIBUTION OF SEEDS OF LITTLE BLUE GRAPE SELF-POLLINATED AND OPEN TO CROSS-POLLINATION.

Sp. gr.	Self-pollinated.	Open to cross-pollination.
<1.00	728.	390.
1.01	4.	
1.02	10.	6.
1.03	6.	6.
1.04	5.	12.
1.05	12.	12.
1.06	9.	6.
1.07	10.	12.
1.08	15.	12.
1.09	13.	18.
1.10	48.	42.
1.11	49.	42.
1.12	56.	156.
1.13	98.	204.
1.14	28.	84.
1.15	10.	78.
1.16	3.	24.
	1104.	1104.

SEPARATION OF FOREIGN MATTER FROM SEEDS BY MEANS OF SOLUTIONS.

The method of separating seeds by salt solutions can sometimes be applied to the separation of foreign matter or foreign seeds from the desired seeds. It is admitted, however, at the outset that this consideration is of very minor importance. In separating a lot of clover seed, the highest separate was found to consist almost entirely of gravel and other inert matter. In separating a lot of timothy, the separate above 1.30 consisted almost entirely of foreign seeds, apparently clover seed. In separating another lot of clover seed it was noticed that many of the seeds in the highest separate were foreign leguminous seeds quite similar in size and appearance, however, to the clover seed. The separates were planted and the results are shown in Plate XVI, fig. 3. It is here seen that the larger part of the plants in these higher separates are of a foreign species. These seeds were too nearly of the size of clover seed to have been separated by sieving; but they could have been gotten rid of in larger part by discarding all seeds above 1.33, and almost entirely by discarding all seeds above 1.28. In so doing but comparatively few clover seeds would have been lost.

Garman[1] makes mention of a practice of separating the seeds of certain morning glories that grow among hemp from hemp seed by immersing the seed in water.

[1] Kentucky Agricultural Experiment Station Bulletin 105, p. 19.

The method of solutions is apparently not of much use, however, for separating different kinds of seeds from each other. This is because seeds of different kinds are distributed over so wide a range of density that the separates commonly very much overlap. Even in the occasional instances in which it is desired to separate a heavy seed as a legume or cereal from some light seed, the use of a fanning mill would commonly be more convenient.

RELATION BETWEEN SIZE AND SPECIFIC GRAVITY OF SEED.

Noteworthy correlations exist between the size of the seed and its specific gravity. In this connection, by the word size is meant volume, that being the common use of the term as applied to seeds. In illustration of this correlation the figures in Table III may be cited. Prof. Beach had separated grape seeds into different lots according to their smallest diameter as indicated in the table. Among seeds of different diameters which were thus separated, those that were noticeably plump were selected by the eye and classified separately. They are designated as "very plump" in the table. It will be noticed that these seeds are almost all good and fall within the range of seeds of high quality. This observation simply emphasizes once more the old horticultural truth, that the plumpest seeds are the best.

TABLE III.—DISTRIBUTION OF SEEDS OF MABEL GRAPE ACCORDING TO SIZE AND OF EACH SIZE ACCORDING TO SPECIFIC GRAVITY.

SIZE OF SEED.	<1.00	1.00	1.01	1.02	1.03	1.04	1.05	1.06
Very small	2							
Small	12	2	1	1	1	1	1	1
Small, very plump	2							1
Medium size	42		2		3	2	11	21
Medium size, very plump	2	1					1	3
Large				1			2	2
Large, very plump		1					3	4
Very large								

SECOND SECTION OF TABLE III.

SIZE OF SEED.	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	Total.
Very small...............										2
Small....................	2	6	5	5	7	3	4		2	54
Small, very plump.........	1	1	1	2	4		1			13
Medium size..............	23	43	39	54	64	18	9	1		332
Medium size, very plump...	4	6	7	16	10	3				53
Large....................	1	8	9	14	4					41
Large, very plump........	3	3	3	6			1			24
Very large...............		1								1

It will be noticed that all of the seeds in the smallest lot are lighter than water. This observation applies to grape seeds in general. In the next larger size there are relatively a large number of floaters. Only the seeds of highest specific gravity germinated. In the case of the variety (Mabel) shown in this table the percentage of germination among the small seeds was less than what it commonly is with such vigorous and self-fertile varieties as Concord. It is noticed from the table also that as the size of the seed increases the number of light seed decreases; but at the same time the maximum range of the heavier seed becomes less and less. This observation also is of general application. In the seeds of largest diameter there are very few light seeds. In the table the range within which germination took place is included within the irregular line.

These facts as to the distribution of seeds of different sizes through the range of specific gravity are shown in graphic form in Chart II. A glance at this chart shows immediately that the great mass of seeds are of medium size, which would have been anticipated. The small seeds are numerically greater in number than the large ones, but fewer of them fall within the range of germinable seeds. On the other hand almost all of the large seeds are seen to be of good quality. The medium sized seeds are seen to fall in larger part within the range of good seed.

TABLE IV.—SHOWING RELATIVE DISTRIBUTION OF GRAPE SEEDS OF DIFFERENT SIZES AS REGARDS SPECIFIC GRAVITY.

Sp. gr.	Small.	Medium sized.	Large.
	Per ct.	*Per ct.*	*Per ct.*
<1.00	21.	11.	2.
1.00	3.		
1.01	2.	1.	
1.02	2.		2.
1.03	2.	1.	
1.04	2.	1.	
1.05	2.	3.	8.
1.06	3.	5.	9.
1.07	4.	7.	6.
1.08	10.	13.	17.
1.09	9.	12.	18.
1.10	10.	18.	31.
1.11	16.	19.	6.
1.12	4.	6.	
1.13	7.	2.	1.
1.14		1.	
1.15	3.		
	100.	100.	100.

The distribution of the seeds of each of these sizes in percentages of the total number of seeds in each size is shown in Table IV and graphically in Chart III. Although Charts II and III represent the same sample of seed, the appearance of the two charts is quite different. Chart III shows that almost the entire percentage of larger seed falls within the range in which germinations occur; that a less percentage of medium sized seeds falls within that range, and a still less percentage of small seeds. The number of poor seeds is obviously in inverse proportion to the number of good seeds. This chart brings out forcibly the fact that a conventional separation of seeds by a salt solution without having previously separated the seeds into lots of different sizes is of itself a partial separation according to size; that is, the lighter separates consist predominantly of the smaller seeds, and the smaller the seeds the greater the proportion of them contained in the lighter separates. Inversely, the heavy separates contain a larger portion of large seeds than does the original sample and the larger the seeds the larger the proportion of them which is included.

Charts II and III and their respective tables bring out anew the fact that the seeds of highest specific gravity absolutely are small seeds, and that the larger the seed, the less high does it range in specific gravity, though the average specific gravity of large seeds is greater than that of small seeds. This observation is of general application. For instance, in the case of cabbage and cauliflower the maximum specific gravity of small seeds is about 1.21; but none of the large seeds run as high as 1.20.

As a rule, as has already been stated, the seeds largest in volume have the fewest floaters among them; but there are some notable exceptions. For instance, in a lot of egg plant seed examined, all of the largest seeds were floaters. These seeds were actually the heaviest in milligrams of all seeds in the package and were to all outward appearances the finest seeds in the lot. They were closely examined with a view to discovering some outward indication of their lightness, but none was found. But in the case of egg plant the general rule also holds good that the smallest seeds are in large part floaters.

Schertler found that specific gravity increases with the size of the seed. For practical purposes this statement is correct, but strictly it is only a half truth. The author's investigations were presumably made by the method of samples, and this method would lead to this error, since the method of samples does not show distribution, but only averages. The fact is, as has already been brought out, that small seeds attain to the highest specific gravity; but there are so many small seeds of low specific gravity that the *average* specific gravity of small seeds is less than that of large seed. Schertler's observation that abnormally large seeds have a less specific gravity than do good medium sized ones agrees with the observations of the present writer. Lyon concludes that large kernels of wheat are generally of higher specific gravity than are small ones, and gives figures showing the proportion of light seed in small, medium and large seed.

RELATION BETWEEN SPECIFIC GRAVITY OF SEED AND VIGOR OF GERMINATION.

Noteworthy correlations also exist between the specific gravity of the seed and its vigor of germination. Moreover the ranges within which seeds germinate most vigorously, less vigorously or not at all may be rather closely delimited. In anticipation of a later discussion in this report, it may be remarked that vigor of germination appears to be associated with storage of reserve material, and that in the range of specific gravity which represents the largest storage of reserve material the most vigorous germination is found. Correlated with a less storage of reserve material is a less vigorous germination. With many kinds of seed the lightest ones do not germinate at all or only sparingly. Most conspicuous is this last in the case of seeds enclosed in a firm seed coat, such as grape and solanaceous seeds. Many such are found to be lighter than water and are generally hollow.

The ranges of specific gravity representing different vigors of germination may be mentioned for a few kinds of seed:

In the case of grapes, germination is very rare below 1.07 to 1.04 according to the variety. Over a range of several one-hundredths above these points germination is infrequent. In the case of several kinds of leguminous seeds examined, germination had not taken place below 1.18 or thereabouts. In the case of common field clover there was in one case no germination below 1.17 and in a sample of crimson clover, known to be at least one and a half years old, there was no germination below 1.23. Wheat gave no germination below 1.18. Egg plants give very few germinations below 1.00 and perhaps these few germinable seeds could have been separated from the others by the use of a solution slightly lighter than water.

MUSTARD.

Germination tests with mustard gave the results reported in the following table. The seeds were set in filter paper April 10 and the first germinations observed April 13.

TABLE V.—SHOWING CORRELATION BETWEEN SPECIFIC GRAVITY OF MUSTARD SEED AND RAPIDITY AND PERCENTAGE OF GERMINATION.

Sp. gr.	No. of seeds.	Germinated. April 13.	Germinated. April 14.	Germinated. April 15.	Germinated. April 22.
1.01	1.				
1.08	1.			1.	
1.09	2.				
1.10	1.				
1.12	5.	1.		1.	
1.13	5.	2.		2.	
1.14	15.	10.	2.		1.
1.15	17.	10.	3.	1.	
1.16	16.	8.	2.	1.	2.
1.17	10.	6.	1.	1.	1.
1.18	3.	1.	1.		
1.19	10.	5.	2.		2.
1.20	2.				1.
1.21	1.				
	89.	43.	11.	7.	7.

From these figures it may be computed that 48 per ct. of all the seeds set germinated the first day of germination. Between 1.14 and 1.17 inclusive fifty-eight seeds are included and of these, thirty-four, or 59 per ct., germinated in the same time. All others are thirty-one seeds, of which nine, or 29 per ct. only, germinated the third day. It thus appears that the best germination in all respects took place between 1.14 and 1.17. The reserve material in cruciferous seeds is characteristically in the form of oil, and Kobayashi, as already stated,* has shown that the greatest percentage of oil is contained in cruciferous seeds of medium specific gravity. This one trial would indicate, then, that vigor of germination is correlated with storage of reserve material.

TIMOTHY.

Tests with timothy seed resulted as follows:

Table VI.—Showing Relative Vigor of Germination of Timothy Seed of Different Specific Gravities.

Sp. gr.	Germination. Per ct.	Remarks.
1.00	30.	
1.00–1.10	40.	
1.10–1.20	40.	
1.20–1.26	75.	Very vigorous
<1.26	90.	do.

Timothy seed does not lend itself well to separation by salt solutions, at least in the small way in which the writer has conducted his experiments. Perhaps on a large scale, especially where a quantity of seed was being separated in a large receptacle, the method would be applicable. It appears from these results that, as a matter of agricultural practice, it would be easy to get rid of a large part of the ungerminable seeds in fresh timothy seed by simply immersing the seed in a saturated salt solution (1.20) and planting only the seeds which sank.

CLOVER.

A sample of fresh clover seed showed in the separates less than 1.20 only three germinations out of sixteen seeds. These separates consisted mostly of small (foreign) seeds. The percentage of germination in the separates 1.20 to 1.24 was low. Between 1.25 and 1.30 the percentage of germination was high. Above 1.30

*See page 339 of this report.

the percentage was again low, being only about fifty per ct., and many foreign seeds were intermixed.

In a sample of another variety of clover germination was practically complete up to 1.27, above which it was low.

In the case of another sample of common clover there was no germination below 1.17 and only three below 1.20. From 1.20 up germination was good but in the higher ranges the seeds proved to be mostly of a foreign leguminous species. These seeds were planted in a single row about two rods long. In Plate XVI are shown the range from 1.20 downward (Fig. 1), the plants from seed of specific gravity of 1.23 to 1.26 (Fig. 2), which were the best separates in the lot, and the separates from 1.27 up (Fig. 3.) From 1.27 to 1.33 many plants of another smaller leguminous species are seen to be intermixed, and from 1.33 up they are seen to constitute almost the entire growth.

CHAMPION OF ENGLAND PEAS.

One hundred Champion of England peas were separated with the result shown in the table below. These separates were put under test at three o'clock, December 8, 1903. The first germinations were observed at eight o'clock on the morning of December 11, sixty-six hours later. These germinations were noted and are separately recorded in the table. Other germinations occurred during the next forty-eight hours, but not later, although the test was continued for two days after the last germination was observed. The total germinations are also shown in the table.

TABLE VII.—SHOWING DISTRIBUTION OF CHAMPION OF ENGLAND PEAS AS REGARDS SPECIFIC GRAVITY; ALSO SHOWING NUMBER OF GERMINATIONS IN FIRST SIXTY-SIX HOURS AND TOTAL NUMBER OF GERMINATIONS.

Sp. gr.	No. of seeds.	Germinations in 66 hours.	Total germinations.
<1.00	2.		
1.000–1.025			
1.025–1.050			
1.050–1.075	1.		
1.075–1.100	1.		
1.100–1.125	2.		
1.125–1.150	3.		1.
1.150–1.175	3.		
1.18	2.		
1.19	8.	4.	8.
1.20	8.	3.	7.
1.21	4.	2.	4.
1.22	4.	2.	3.
1.23	4.	3.	3.
1.24	5.	2.	4.
1.25	6.	3.	5.
1.26	9.	4.	5.
1.27	10.	6.	10.
1.28	20.	12.	18.
1.29	4.	4.	4.
1.30	2.	2.	2.
1.31	1.	1.	1.
	100.	48.	75.

These data are shown graphically in chart IV.

From this table, as also from the chart, it appears that among the 100 seeds set, 85 were in the range from 1.19 and above and 15 were in the range below 1.19. Of the 85 seeds in the higher range, 74 germinated in all, or 87 per ct. Of the 15 seeds in the lower range, only one, or 6.6 per ct. germinated, and this germination was very weak. Of the 74 germinations in the higher range, 48 occurred the first day of germination, or 65 per ct. The one germination below 1.19 did not occur until the second day later. It appears, then, that if one should make up a solution of common kitchen salt to its maximum density (1.20) and separate Champion of England peas by this means, he could separate out nearly all of the germinable seeds and discard a considerable part of the poor seeds.

In the course of the observations on the relative vigor of germination of peas of different specific gravities reported in Table VII, it was noticed that among those seeds which had germinated in the first sixty-six hours, some had germinated either earlier or else much more vigorously than others. An effort was made in a crude way to compare the relative vigor of germination of these different seeds by measuring the length of the radicles. These measurements are recorded in the following table:

Table VIII.—Lengths of Radicle Made by Peas of Different Specific Gravities During the First Sixty-six Hours of Germination.

Sp. gr.	No. of seeds.	Length of radicle in 32ds of an inch.	Average length in 32ds of an inch.
1.31	1	4	4
1.30	1 1	6 2	4
1.29	1 1 1 1	5 7 1 4	4.25
1.28	2 2 1 2 1 1 2 1	1 2 3 4 7 10 11 15	6
1.27	2 2 1 1	1 2 4 6	2.66
1.26	2 1 1	1 3 6	2.75
1.25	1 1 1	* 1 3	1.33
1.24	1 1	* 1	.5
1.23	1 1 1	2 9 5	5.33
1.22	1 1	2 8	5
1.21	1 1	1 4	2.5
1.20	1 1 1	* 2 3	1.66
1.19	2 2	* 2	1

* Testa broken but radicle not yet protruding.

No correlations stand out very clearly in this table; but nevertheless seeds of high specific gravity, that is 1.28 and above, made quite uniformly a vigorous germination. On the other hand seeds of low specific gravity made considerable less vigorous germination, though very unequally so. This is most noticeable in the three lowest separates. In addition, as has already been pointed out, the percentage of germination among the seeds of higher specific gravity was high while the percentage among seeds of lower specific gravity was low.

CORRELATIONS BETWEEN SPECIFIC GRAVITY OF SEEDS AND THEIR COLOR.

Correlations have occasionally been noticed to exist between the specific gravity of the seed and its color. For instance, the purplish, immature seeds of grape which are often observed, especially in varieties imperfectly self-fertile, are almost always floaters or in a few cases have a specific gravity slightly above 1.00. The dark colored seeds which are often seen in the Solanaceæ, as in egg plant and pepper, are, so far as observed, always of low specific gravity and mostly floaters. In the case of the tomato a few brown seeds are high in specific gravity, but the numerical proportion of them to the whiter seeds rises very rapidly as specific gravity decreases.

The result of a germination test with pepper seeds of different colors (and sizes) is shown in the upper figures of Plate XVII.

The row at the extreme left (in both figures) was grown from large white seeds and contains twenty-one plants. In the next row, grown from medium sized white seeds, are sixteen seedlings. In the third row, from small white seeds, are eight seedlings. In the fourth row, from rather brownish seeds of various sizes, are ten seedlings, and in the fifth row, from dark colored seeds of different sizes, are five seedlings. In each case twenty-five seeds were planted in each row. The very differing vigor of growth in the different lots is shown in Fig. 1, and something of the very unequal germination in Fig. 2, which is another view of the same lot. It is seen that brownish seeds, irrespective of size, produce but little better seedlings than do small white seeds, and that the seedlings are inferior in vigor to those from medium sized white seeds. Further, dark colored seeds germinate very scantily indeed and produce very weak seedlings. Unfortunately these seeds were not separated according to specific gravity, but trials with other seeds of the same variety showed that all dark brown seeds and the larger part of the light brown ones are floaters. All pepper seeds at all discolored are low in specific gravity.

Wolffenstein believed that he had found a correlation between color of wheat kernels and their specific gravity. The present writer has verified this observation. In the case of wheat the difference in color is due to differences in gluten content, as Snyder* has pointed out. The higher the specific gravity the larger the percentage of gluten, which is dark in color.

RELATION BETWEEN SPECIFIC GRAVITY OF SEEDS AND THEIR VIABILITY.

There is some evidence that a correlation exists between the specific gravity of a seed and its viability. For instance, in the case of a sample of mustard seed (see Table V), known to be at least one and a half years old, the specific gravities ranged from 1.01 to 1.21; the only germinations which took place, however, on the first day of germination were between 1.14 and 1.19. Not until the second day after did any germination take place among the seeds lying between 1.13 and 1.01, below the optimum of distribution, nor in the separates 1.20 and 1.21, above it. In all, eighty-nine seeds were set, of which eighty-one lay between 1.12 and 1.19, and of these forty-three, or 53 per ct., germinated the first day of germination, and 66, or 82 per ct. in the entire test. Outside of these limits, both above and below, were eight seeds, none of which, as stated before, germinated until the third day of germination, and in the entire test only two of these, or 25 per ct., germinated.

In the case of some seeds of the Swedish turnip, also old, only 12 per ct. of those below 1.12 germinated and all of these very weakly. Of the seeds in the separates 1.12 and 1.13, 31 per ct. germinated and the seedlings were generally vigorous. Above 1.13 to 1.17 (the maximum) only one germination occurred. Ordinary germination tests showed that the percentage of germination in these particular samples of seed was very low. While

*Minn. Agr. Exp. Sta., Bul. No. 85.

opportunity was not afforded for comparing these results with the germination of new seeds, it may be confidently stated that the percentage of germination among normal, fresh seeds would have been much higher than those here given.

A sample of old crimson clover seed was also separated. There were no germinations below 1.23. Judging from experience with other kinds of clover and other leguminous seeds, it appears probable that fresh crimson clover would show germination below 1.23.

If the correlation between viability and specific gravity here suggested is found to exist actually, it immediately becomes practicable to separate in advance from a lot of seeds those which would soonest become non-germinable. This might be desirable in cases in which it was desired to keep seeds for several years.

RELATIVE SPECIFIC GRAVITY OF SEEDS MOIST AND AIR DRY.

Seeds in the moist condition, such as grape seeds fresh from the berry, generally do not have the same relative specific gravity as do seeds in the air dry condition. This point was brought out in observations on seeds of the Black Hamburg grape which were examined on the same day they were taken from the fruit and again about two and a half months later. The results are shown in the following table:

TABLE IX.—SPECIFIC GRAVITIES OF SEEDS OF BLACK HAMBURG GRAPE FRESH FROM THE BERRY AND AGAIN AIR DRY.

No. seeds.	Specific Gravity.	
	Fresh.	Air dry.
11	<1.00	<1.00
1	1.01	<1.00
2	1.02	<1.00
1	1.03	<1.00
1	1.04	1.02
2	1.06	1.03
1	1.06	1.04
1	1.07	1.06
1	1.07	1.05
2	1.08	1.04
1	1.08	1.06
3	1.09	1.08
2	1.09	1.06
2	1.09	1.05
3	1.10	1.08
5	1.10	1.07
2	1.10	1.05
1	1.10	1.04
1	1.10	1.02
6	1.11	1.09
6	1.11	1.08
1	1.11	1.07
1	1.11	1.06
1	1.12	1.10
7	1.12	1.09
9	1.12	1.08
2	1.12	1.07
1	1.12	1.06
3	1.13	1.10
3	1.13	1.09
3	1.14	1.10
12	1.14	1.09
5	1.14	1.08
16	1.15	1.10
7	1.15	1.09
4	1.15	1.08
1	1.15	1.07
5	1.17	1.11
6	1.17	1.10
3	1.17	1.09
2	1.18	1.12
1	1.18	1.10
1	1.18	1.08
1	1.19	1.14
2	1.20	1.12

This table emphasizes the need of having seeds in the air dry condition when specific gravity determinations are to be made. It shows also that the method of specific gravity is less applicable to seeds which must be kept moist in order for them to germinate. Among such are apple seeds and various other seeds which it is customary to stratify in the fall. At the same time these observations show that the specific gravity of the fresh seeds follows in a general way, though irregularly, the specific gravity of the air dry seed.

Schindler concludes from his investigations that the capacity of pees for swelling is in general the greater the less their specific gravity. According to the writer's observation, this general principle appears to apply to cruciferous seeds, though no systematic observations have been made. But in the case of some, though not all, peas of abnormally low specific gravity, the principle does not apply at all. For instance in one series of observations one pea having a specific gravity of 1.02 changed only to 1.01 in twenty-four hours, another seed of specific gravity 1.08 changed to only 1.07, and a third seed of specific gravity 1.09 changed only to 1.05. In the same period of twenty-four hours normal, germinable seeds of specific gravity 1.24 to 1.31 changed variously from 1.09 to 1.02. Doubtless the reason for the very slight change in specific gravity of the non-viable seeds is the well known physiological fact that dead seeds cannot swell.

Incidentally it was brought out in the course of these observations that seeds of abnormally low specific gravity often contain an exceptionally high content of moisture when in the air-dry condition; for instance the seed referred to above of specific gravity 1.02 contained twenty-two per ct. of moisture and the seed of specific gravity 1.09 contained 18.6 per ct. Viable seeds in the same lot contained generally from 11 to 13 per ct. But all peas of abnormally low specific gravity do not contain an excessive amount of moisture, as is shown by the fact that a pea of specific gravity 1.08 contained only 13 per ct.

RELATION BETWEEN SPECIFIC GRAVITY OF SEED AND VIGOR OF RESULTING PLANTS.

The writer has made but few culture tests to determine whether there is a correlation between the specific gravity of the seed and the vigor and productiveness of the resulting plant, and none of these tests are satisfactory. They were made in the season of 1903, when the exceptional period of drouth early in the season put the crops back; and later disease or other untoward circumstances interfered, lessening confidence in the comparability of the results obtained. Some of these results are nevertheless believed to be sufficiently reliable to be worthy of being placed on record.

CARROT.

Trials with carrot seed gave the following results:

TABLE X.—RESULTS WITH CARROT SEED.

Sp. gr.	No. large plants.	Average weight.	Small plants additional
	(50 large seeds.)	*Ozs.*	
<1.00	3	14	5
1.00–1.03	2	13	1
1.03–1.06	2	12	1
1.06–1.09	1	17	
1.09–1.12	2	11	
1.12–1.15			No germination.
	(50 small seeds.)		
1.00	3	7	1
1.06–1.09	2	7	
1.09–1.12	3	9	

Little, if any, effect, on the vigor of the plants appears to be attributable to specific gravity. Size of seed is, however, seen to be very important.

SWEDISH TURNIPS.

The seed used in this test was low in percentage of germination. The plants grew as they came up in the row and did not need thinning.

TABLE XI.—RESULTS WITH SWEDISH TURNIPS.

Sp. gr.	Weight of roots.	
	Ozs.	
<1.00	18	
1.00–1.03	5	Average 9 ozs.
	5	
	13	
1.03–1.06	5	
	37	
	12	
	9	
	34	
1.06–1.09	23	Average 19 ozs.
	19	
	7	
	41	
1.09–1.12	19	
	21	
	5	
	29	
1.12–1.15	22	
	69	
	64	Average 42 ozs.
	32	
	28	
1.15–1.18	53	

The results in the above table are shown in Plate XVII, fig. 3. These figures would indicate apparently a very striking correlation between specific gravity of seed and vigor of the resulting plants; but the writer has not yet separated Swedish turnip seeds by sieving and the striking differences shown in this table may be found to be due to a grouping of the seeds according to size.

CAULIFLOWER.

The tests with cauliflower did not at first promise results and for this reason four heads which did form early in the fall were cut and no record was made of their weight. Later, other plants came on and their records are given herewith. The variety used in this test was Autumn Giant.

TABLE XII.—CULTURE TESTS WITH CAULIFLOWER SEEDS OF DIFFERENT SPECIFIC GRAVITIES.

Sp. gr.	Weight of head.	Weight of leaves.
	Ozs.	*Ozs.*
	(Large seed.)	
1.00–1.03	10	54
1.03–1.06	12	44
1.03–1.06	20	59
1.06–1.09*	5	40
1.12–1.15*	17	66
	(Small seed.)	
1.12–1.15	4	66
1.12–1.15	4	66
1.12–1.15	6	56

* Two other plants in this lot had been cut early in the season.

It is regretable that all of the plants in this experiment were not preserved intact. It will be noticed, however, that all four of the plants which were harvested early were from large seed of medium or high specific gravity. In one of these groups was found the heaviest head, with one exception, of any weighed. If a single test like this indicates anything at all, it indicates that the largest cauliflower heads are grown from large seeds of medium or high specific gravity.

LATE STONEHEAD CABBAGE.

Trials of this variety of cabbage gave results as follows:

TABLE XIII—RESULTS WITH LATE STONEHEAD CABBAGE.

Sp. gr.	Weight of head.	Weight of leaves.	Remarks.
	Ozs.	(Large seed.) *Ozs.*	
<1.00	21	10	Hard.
1.00-103	41	34	Hard.
	39	29	Soft.
	47	30	Soft.
1.06-1.09	66	33	Hard.
	50	41	Hard.
	43	23	Hard.
1.09-1.12	28	27	Soft.*
	12	34	Very soft.*
1.12-1.15	21	24	Medium
	24	16	"
	(Small seed.)		
1.00-1.03		31	No head.
		30	"
1.06-1.09	9	33	Fluffy.
	24	43	Very soft.
	54	20	Hard.
1.12-1.15	19	31	Very soft.
		65	Almost no head.
		16	" "
1.15-1.18	16	24	Very soft.
		37	Almost no head.
		13	No head.
1.16-1.21	22	20	Hard.
	29	24	"

*Root system very weak.

This table does not bring out clearly the correlation of any cultural property with specific gravity. It does appear, however, that large seeds are better for planting than small seeds, which is an observation of general application. It appears also that large seeds give firmer heads than do small seeds; and in general this observation also holds good with cabbages so far as the writer's experience extends.

EARLY JERSEY WAKEFIELD CABBAGE.

In one part of this test comparisons were made of seeds of different sizes and colors, the comparisons being between 10 very small reddish seeds, 10 medium sized reddish seeds, 10 medium sized black seeds, 6 large red seeds, and 10 large black seeds. In the other part of the test seeds were selected of different sizes from the smallest to the largest and their individual weights and later specific gravities taken. The results are shown in the following table:

Table XIV.—Results with Early Jersey Wakefield Cabbage.

Sp. gr.	Wt. of seed Mg.	Date harvested.	Weight of Head. Lbs.	Weight of Head. Ozs.	Weight of Leaves. Lbs.	Weight of Leaves. Ozs.	Remarks.
			10 very small reddish seeds.				
1.20							Did not germinate.
1.18		Oct. 3	1	12	2	0	Firm.
1.15		Aug. 22	2	13	2	0	Medium.
1.13		Aug. 22	4	2	2	5	Firm.
1.13		Oct. 3					Did not head.
< 1.00							Did not germinate.
< 1.00							Did not germinate.
< 1.00							Did not germinate.
< 1.00							Did not germinate.
< 1.00							Did not germinate.
			10 medium sized reddish seeds.				
1.16							Did not germinate.
1.15		Oct. 3	4	5	3	3	Slightly cracked.
1.15		Aug. 22	3	1	1	2	Firm.
1.13		Oct. 3	3	1	2	5	Firm.
1.12		Aug. 22	3	5	2	3	Firm.
1.10		Aug. 22	5	4	2	10	Firm.
1.10		Oct. 3	2	7	2	0	Medium firm.
1.09		Oct. 3	5	4	3	5	Medium firm.
1.09		Aug. 22	2	3	1	10	Medium firm.
< 1.00							Did not germinate.
			10 medium sized black seeds.				
1.15		Aug. 22	2	9	3	2	Rather soft.
1.13		Aug. 22	3	12	3	12	Rather soft.
1.13		Oct. 3	5	0	2	0	Firm.
1.13		Aug. 22	4	7	2	5	Medium firm.
1.11		Aug. 22	2	15	1	2	Hard; cracked open.
1.11		Aug. 22	1	13	2	9	Hard; cracked open.
1.11		Aug. 22	1	3	2	2	Rather soft.
1.11							Did not germinate.
1.09		Aug. 22	2	7	1	8	Rather soft.
1.03							Did not germinate.
			6 large red seeds.				
1.15		Aug. 22	0	8	0	8	Soft.
1.14		Oct. 3	2	0	4	2	Soft.
1.13		Aug. 22	4	2	1	3	Firm, badly cracked.
1.13							Did not germinate.
1.13							Did not germinate.
< 1.00							Did not germinate.

TABLE XIV.—*Continued.*

Sp. gr.	Wt. of seed Mg.	Date harvested.	Weight of Head. Lbs.	Weight of Head. Ozs.	Weight of Leaves. Lbs.	Weight of Leaves. Ozs.	Remarks.
			10 large black seeds.				
1.18							Plant dried out.
1.11		Oct. 3	7	10	5	2	Firm.
1.11		Aug. 22	2	9	2	4	Firm.
1.10		Aug. 22	3	3	2	4	Firm.
1.10		Oct. 3	2	10	2	5	Moderately firm.
1.09		Aug. 22	2	12	2	7	Firm.
1.09		Aug. 23	1	9	1	8	Rather soft.
1.07		Oct. 3	9	14	5	14	Hard.
< 1.00		Oct. 3	2	9	0	13	Hard, decayed.
< 1.00							Did not germinate.
1.16	1.4	Aug. 22	3	9	2	2	Medium hard.
1.16	1.6	Oct. 3	6	4	2	9	Hard.
1.17	1.8	Oct. 3	5	14	2	6	Hard.
1.16	2.0	Aug. 22	3	3	2	2	Firm.
1.13	2.0						Did not germinate.
1.15	2.2	Oct. 3	5	0	3	11	Firm.
1.06	2.2	Oct. 3	1	10	1	15	Rather soft.
1.15	2.4						Died.
1.13	2.8	Aug. 22	2	11	1	6	Soft.
1.17	3.0	Aug. 22	5	3	2	8	Rather firm.
1.16	3.0						Did not germinate.
1.13	3.0	Aug. 22	3	8	2	0	Firm.
1.14	3.2	Aug. 22	1	10	0	14	Hard, badly cracked.
1.13	3.4	Aug. 22	5	2	2	10	Firm.
1.11	3.4	Aug. 22	3	10	2	10	Firm.
1.10	3.4	Aug. 22	4	8	1	12	Firm.
1.09	3.6						Died.
1.06	3.6	Aug. 22	4	8	2	10	Medium firm.
1.11	4.0	Aug. 22	3	6	1	9	Firm.
1.09	4.0	Aug. 22	3	7	1	10	Hard, badly cracked.
1.14	4.4	Oct. 3					Did not head.
1.13	4.4	Oct. 3	6	0	2	5	Firm.
1.10	4.4						Did not germinate.
1.14	4.6						Died.
1.09	4.8						Did not head.
1.11	5.0						Died.
1.09	5.0						Did not germinate.
1.09	5.6						Did not germinate.
1.15	5.8	Aug. 22	1	5	1	0	Rather soft.
1.11	6.0						Did not germinate.
< 1.00	6.0	Aug. 22	4	2	1	5	Firm.
1.14	6.4						Died.
1.14	6.4						Died.
< 1.00	6.4	Oct. 3	5	9	1	12	Hard.
1.17	6.6						Did not head.
1.11	7.2	Oct. 3	4	2	1	11	Hard.
1.05	7.4						Dried out.

This table brings out anew the fact that the percentage of germination among very small seeds is low; also that such seeds as do germinate produce small plants. As regards the difference between reddish and black seeds, both of medium size, it would appear that plants from the black seeds are a little earlier than those from the reddish seeds, since more of the plants from the black seeds were ready for harvesting in August. In the case of the large red seeds the percentage of germination was low. Whether this was due to chance or not the writer cannot say.

The heaviest yielding plants were those from the large black seeds.

This table brings out a point in regard to the germination of cruciferous seeds which the writer has often observed, namely, that no floaters germinate except some of those of large size.

It would appear from the second part of the table that seeds medium to large in size are earlier than those either very small or very large. But all of these results with cabbage are unsatisfactory.

EGG-PLANT.

Records of the results of culture tests with seeds of egg-plants of different specific gravities are shown in Table XV. Much the larger part of all the seeds planted failed to germinate; but practically every seed of a specific gravity of 1.00 or above did germinate. The seeds used in this test were purchased of one of the leading seed houses in America and were especially certified for the purposes of this experiment to have been produced the year before. It is well-known that egg-plant seed of the best quality is of a low percentage of germination; but the results of this test indicate that nearly all of the ungerminable seeds might be separated from such a sample by the mechanical method of solutions and thereby the dealer could offer an article known to be of high quality and at the same time showing a high percentage of germination.

TABLE XV.—RESULTS WITH EGG-PLANT.

Sp. gr.	Weight of plant.	No. of fruits.	Total weight of fruits.	
	Ozs.	Fifty light colored seed.	Ozs.	
<1.00	12	1	1	
	9	1	<1	
	7	1	1.5	
	22	3	5.5	
	2	—	—	No fruit.
	17	1	3	
	27	4	3.5	
		Forty-five black seeds.		
1.00	15	1	<1	
	9	—	—	"
	11	—	—	"
	20	1	<1	
	20	—	—	"
	16	1	<1	
	11	—	—	"
	21	1	<1	

TABLE XV.—RESULTS WITH EGG-PLANT—*Continued.*

Sp. gr.	Weight of plant.	No. of fruits.	Total weight of fruits.	
		Light colored seeds.		
1.00	24	3	3	
	9	—	—	No fruit.
1.01	19	1	2	
	38	3	9*	
	8	—	—	"
1.03	9	2	1	
	19	1	6	
1.04	8	1	1.5	
	9	1	3	
	16	3	5	
	9	—	—	"
	24	2	2.5	
1.05	28	4	8.5	
	36	2	7	
	14	1	3	
1.06	18	1	4.5	
	22	1	2	
1.08	27	1	<1	
1.09	12	1	1	

* One of these fruits alone weighed 8 ounces.

Individual record is not made in this table of the seeds which did not germinate; but as has just been stated, they were practically all of a specific gravity less than that of water. By floating the seeds off in water a few germinable seeds were floated off at the same time; but an inspection of the table above shows that in not a single instance did any such seed produce a first-class productive plant. Out of fifty light colored seeds planted only six bore fruits at all, and the average weight of these fruits was only a little over one ounce. Among forty-five black seeds all of a specific gravity less than 1.00, eight germinated, but only four of these produced any fruit and in every case the weight of the fruit was less than one ounce. It appears, then, that if one should float off egg-plant seed in pure water, he would be throwing away no seed of high quality. At the same time he would by this mechanical method be getting rid of practically all of the black seeds, which are mostly floaters and which uniformly produce considerably less vigorous plants than do light colored seeds of the same size.

As has already been said, germination was practically perfect among the seeds of a specific gravity 1.00 and above. Of such plants which lived through the season (two or three had died) sixteen out of nineteen produced fruit, and the average yield per plant for the whole lot was 3.75 ozs., or three times as much as was produced by germinable seeds of specific gravity less than 1.00.

PEPPER.

A part of the seedling peppers already described under the head of "Correlations between specific gravity of seeds and their color," were transplanted into the field for further culture tests. From each lot the largest two seedlings and three medium sized ones were selected except in the case of the seedlings from dark colored seeds, in which the largest five were taken. The season was very unfavorable to the growth of these plants and the yields were small, but are believed to be nevertheless comparable. The plants were harvested and records made of the weight of each plant entire, exclusive of roots, also of the number of fruits produced and of their size. The fruits were, however, nearly all too small for market purposes. The larger fruits are indicated by giving the weight of each. The records follow:

TABLE XVI.—RESULTS WITH PEPPERS.

Five plants from	Weight of entire plant.	No. of fruits produced.	Remarks.
	Ozs.		
Dark seed	4	2	Small fruits.
	14	6	Small fruits.
	8	2	Small fruits.
	12	5	Small fruits.
	—	—	Plant died.
Brownish seed	16	10	Small fruits.
	14	4	Fair sized fruits.
	12	5	Small fruits.
	16	6	Small fruits.
	12	3	1 fair sized fruit, weight, 5 oz.
Small white seed	7	4	Small fruits.
	1	0	Very feeble.
	3	0	Very feeble.
	2	0	Very feeble.
	—	—	Plant died.
Medium white seed	6	3	Small fruits.
	12	4	1 fair sized fruit, weight, 5 oz.
	7	2	Small fruits.
	15	3	1 large red fruit, weight, 10 oz.
	11	5	Small fruits.
Large white seed	21	4	1 large red fruit, weight, 15 oz.
	25	6	1 large fruit, weight 16 oz.
	9	0	
	12	4	Small fruits.
	18	8	1 large fruit, weight 10 oz.

It is seen from this table that plants from seeds more or less discolored are as little desirable as yielders as they are unpromising as seedlings. It will be noticed that without exception every large fruit was obtained from a large or in one case medium sized white seeds. Plants from dark seeds did not produce a single fruit large enough for use, and brownish colored seeds produced only two such. None were produced by plants from small white seed.

CAUSES AND DIFFERENCES IN SPECIFIC GRAVITY AMONG SEEDS.

If the specific gravity of a seed is truly related to the vigor of the resulting plant, this fact must presumably be due to differences in composition of the seed. These differences, moreover, must be differences in the relative amounts of reserve material present. The important reserve materials of seeds and their respective specific gravities are as follows:

Fats	0.91—0.96
Legumin	1.285
Protein	1.297
Starch	1.53
Cellulose	1.53
Ash, about	2.50

In addition to the above the seed contains considerable quantities of water (sp. gr. 1.00), and of air (sp. gr. 0.001293). Among the components of the seed the proteids are especially important to the vigorous growth of the plant. It is well known that seeds do vary very greatly in their composition. For instance, Wiley[1] reports differences in the composition of American wheats ranging from 8.58 per ct. to 17.15 per ct. in proteids, 66.67 per ct. to 76.05 per ct. in carbohydrates (excluding crude fiber), and 12.33 per ct. to 39.05 per ct. in wet gluten.

It is well known also that differences in composition are induced by differences in soil, climate, fertilization, and methods of cultural management in general. For instance, as already stated, wheat grown in northern Colorado is heavier than the same variety grown in the Mississippi valley. This is due pre-

[1] Wiley, H. W. (Food and Food Adulterations.) U. S. Dept. Agr. Div. Chem. Bul. 13, pt. 9, p. 1186.

sumably to differences in composition of the grain, though the writer has not figures at hand to support this statement. Soule and Vanatter[2] have recently demonstrated the influence of climate on protein content of wheat, also the influence of fertilizers on the same element. Snyder[3] has also recently called attention to the great differences in protein content that obtain in different varieties of wheat and among different samples of the same variety. Prof. Snyder did not touch on the subject of specific gravity directly, though his investigations are such that his results may to some extent be brought into relation with the work here reported. He showed, for instance, that light colored wheat is lower in protein content than dark colored wheat from the same sample. As already indicated in this report, the light colored kernels are lower in specific gravity than the dark colored ones. We have, then, here a correlation between the specific gravity of the seed and its chemical composition. Prof. Snyder also pointed out the physical basis for these differences in color and showed them to be due to differences in gluten content.

In the case also of the field corn commonly grown in New York State, as has already been stated in this report, the specific gravity is low and the protein content is also well known to be low. But the field corn high in protein content now being grown in the west is relatively high in specific gravity.

These are, however, only particular and isolated cases and do not establish the principle that differences in specific gravity are correlated with differences in composition. The subject of the relation of specific gravity to chemical composition has been investigated by a number of workers but, so far as has come to the writer's attention, uniformly with the conclusion that the one is not a reliable index to the other. This is for the reason that there are so many extraneous factors entering in which are liable to obscure relations. A conclusion of this kind was reached by Wollny, who remarks that in many cases the specific gravity of the seed is an index to its composition, but that there are so many exceptions that in practice no general rule can be laid down. Marek, Wolffenstein and others have reached similar conclusions.

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[2] Bul. Tenn. Agr. Expt. Sta., Vol. XVI, No. 4.
[3] Minn. Agr. Exp. Sta., Bul. No. 85.

SPECIFIC GRAVITY AS RELATED TO RIPENESS.

If the seeds compared are of unequal degrees of ripeness, obviously differences in chemical composition exist. Nowacki found that the specific gravity of wheat decreases from the stage of milk ripeness to that of dead ripeness, and Wollny found the same to be the case with rye. But with peas Wollny found just the opposite changes in specific gravity as related to ripening. The writer has not himself yet investigated the relation between degree of ripeness and specific gravity; but theoretically such a correlation may be assumed to exist, not merely on account of differences in composition but on account of the greater shrinkage which unripe seeds undergo in drying out. Wollny has called attention to this point, as has just been noted, with reference to certain seeds in which the seed coat adheres closely or quite so to the parts within; but Nobbe also calls attention to differences in specific gravity induced in seeds with a rigid seed coat. In this case the endosperm or cotyledon may become slightly reduced in volume in drying out; but the seed coat remains inflexible. If such a change as this actually takes place, the endosperm or cotyledon within would shrink away from the seed coat, leaving a hollow region between. Now just such a hollow region is found in seeds with a rigid seed coat such as grapes, squash, and various other seeds. Whether, however, the seed coat in any of these seeds is completely filled in the unripe seed, or in the seed as it comes fresh from inclosing moist tissues, the writer has not yet made the examinations to determine. If, however, the fleshy parts of seeds do change in volume unequally at different stages of ripeness, it appears probable that selection of seed by specific gravity would be really a selection according to degree of ripeness.

SPECIFIC GRAVITY AS RELATED TO STRUCTURE OF SEED.

Differences in composition are not sufficient to explain the observed differences in specific gravity of seeds. These differences, then, must be sought in differences in structure. In fact, it must be borne in mind that seeds are by no means homogeneous, but are rather porous and are unequally developed in different structural parts. If these differences did not exist, the substance of the seed reduced to powder would have the same specific gravity as the seed itself; but this is by no means the case. For instance, the specific gravity of a certain grape seed was 1.13, but the specific gravity of the substance of the same seed, after having been crushed with a hammer, was about 1.25 for the endosperm and about 1.35 for the outer seed coat. This seeming paradox, that the specific gravity of each part of the seed may be higher than the specific gravity of the seed as a whole is of course explained by the presence of air spaces within.

The experiment just reported brings out clearly the fact that in studying seeds two kinds of specific gravity must be distinguished — *apparent* specific gravity, and *real* specific gravity. These two are, or at least may be, very different from each other. In speaking of the specific gravity of seeds, apparent specific gravity is universally meant, but apparent specific gravity is evidently a property of no practical importance unless it can be correlated with some cultural property.

The writer has made few structural analyses with a view to determining the specific gravities of the component parts of a seed and the relations of these specific gravities to the specific gravity of the seed as a whole. Yet such analyses are indispensable to a correct understanding and interpretation of results obtained in the application of the method of seed selection according to specific gravity.

As to the testa, the specific gravity of this part would appear to be of little effect on the specific gravity of the seed as a whole in the cases of those seeds having very thin covering, such as wheat, since the mass of the testa in these cases forms so small a part of the mass of the seed as a whole. Nobbe reports observations on this point in which it is shown that the thickness of the outer seed coat is only about .04 to .05 mm., varying between those ranges. Obviously the specific gravity of the seed coat in the case of wheat may be disregarded.

In the case of the grape seed, the writer finds the thickness of the testa to vary from .3 to .4 mm. in normal seeds; in hollow seeds it is very slightly less, ranging down to about 2.5 mm. In this case the mass of the testa is great enough to necessitate a consideration of its specific gravity in judging the specific gravity of the seed as a whole. Observations on this point showed, as has already been stated, that the specific gravity of the shell-like covering of the grape seed is about 1.35.

Now as to the relation of the mass of the testa to the mass of the inclosed contents in seeds of different sizes: A number of observations were made, from which it appears that the thickness of the testa of a small seed varies very little or none at all from that of a large seed. From this observation a conclusion of practical importance is deduced, namely, that the higher range of specific gravity observed uniformly to obtain in the case of small grape seeds than of large ones is due simply to the larger proportion of testa in the small seeds as compared with the large ones. For in the case of the small seeds the volumes of the kernel decreases more rapidly than does the volume of the seed coat, since the reduction in diameter falls mostly on the kernel, this leaves an increasingly larger proportion of testa.

Air-dry grape seeds of the highest specific gravity, say from 1.13 to 1.16, reveal no air spaces between the kernel and the seed coat, but beginning at about 1.12 and from there down a slight shrinking away from the seed coat is noticeable. This shrinking uniformly occurs first on the chalazal side of the seed. At a specific gravity of one or two one-hundredths less a separation appears on one side of the seed also. At a somewhat lower specific gravity still, a separation appears on both sides. As the specific gravity of the seed decreases more and more, the volume of unoccupied space within the seed coat increases. It appears then, from these structural differences that, even if the kernel of the seed had in every case the same composition, nevertheless these differences in specific gravity of the seed would appear. Further, given seeds all of the same volume, it appears that the greater the amount of unoccupied space within the seed, the less must be the volume of the kernel and presumably therewith the less the mass of reserve material. Seed selection then, under these or similar conditions, would not in reality be selection according to specific gravity at all in the common understanding of that word, but would simply be selection according to size, and differences in vigor of the resulting plant would have to be attributed to differences, not in specific gravity, but in size. Unfortunately, the writer has not yet made tests to establish or disprove these hypotheses.

So important is it to distinguish between the apparent specific gravity of the seed and the specific gravity of that which is of importance to the plant, *i. e.,* the structural parts in which reserve material is stored, that further studies were made on this point, using material convenient of manipulation. The specific gravities of several buckwheat seeds were determined and then the hulls were removed and the specific gravities were again taken. The records of these determinations are shown in the following table:

Table XVII.— Specific Gravities of Buckwheat Kernels in the Natural Condition and with the Outer Seed Coats Removed.

Sp. gr. of entire seed.	Sp. gr. of seed with testa removed.	No. of seeds.
1.23	1.30	1
1.22	<1.30	2
	1.30	2
	1.28	3
1.21	1.30	1
	1.28	1
1.20	<1.30	1
	1.30	1
	1.29	2
	1.27	1
	1.25	2
	1.24	1
1.18	<1.30 [Small seeds.]	2
	1.30 [Small seeds.]	1
	1.27 [Large seeds.]	1
	1.27 [Large seeds.]	2
	1.25 [Large seeds.]	1
1.14	1.28	2
	1.24	1
	1.22	1
1.07	1.25	1
	1.23	2
	1.22	1
<1.00	1.11	1

From this table it appears that the specific gravity of the kernel follows in a general way that of the entire seed; or in other words, the specified gravity of the entire seed in indicative in a general way of the specific gravity of the kernel within. It appears also from the one set of observations recorded above, that, given two seeds of the same specific gravity, the one large and the other small, the kernel of the small seed is the more compact or else has a larger percentage of the heavier reserve materials in it.

Buckwheat seeds of high specific gravity, that is, above about 1.18, are not large but are very plump and firmly closed at the end. The testa is completely filled by the kernel and the two are separated with comparative difficulty. Beginning at about 1.18 and thence downward, the kernel does not fill the seed-coat completely and the latter is much more easily removed. From about 1.07 down the difference in size between the volume of the kernel and that of the inside of the testa becomes marked, and the seed-coat is very easily separated from the kernel. Seeds of a specific gravity less than 1.00 have a very shrunken appearance and the kernel is very small. Kernels from seeds of high specific gravity are very firm and withstand considerable pressure — as between the fingers — without breaking; but the firmness of the kernel gradually decreases with the specific gravity of the seed, and the kernel from a seed of specific gravity less than 1.00 is so soft that it must be handled very carefully indeed, in order to get it out of the seed coat without breaking it. Further, the kernels of seeds of high specific gravity are solid all the way through but those of low specific gravity are not. In the latter there is more or less of unoccupied space surrounding the embryo which is in the middle of the endosperm and extends from point to base.

From these observations it would appear that differences in structure are abundantly sufficient to account for the observed differences in specific gravity in buckwheat, granting even that the chemical composition of all of the seeds is the same. In this case specific gravity should be set down as of no theoretical value in seed selection as applied to buckwheat. This conclusion is supported by a single culture test which the writer made on a very small scale. In this seed test no conspicuous correlation, if any at all, was found to exist between the specific gravity of the seed and its germination; and, while no measurements were made, the plants from seeds of lowest specific gravity appeared to be as good as those from the highest.

Other seeds also of low specific gravity are in many cases found to present some peculiar characteristic. For instance, in the case of peas it has already been remarked that some seeds of abnormally low specific gravity contain considerably more moisture than do normal air-dry seeds. In another connection some peas of very low specific gravity were examined physically. In this case it was found that the cotyledons were very imperfectly developed and did not completely fill the seed-coat, whereas in normal seeds the cotyledons do fill the seed-coat. In normal seeds the cotyledons are also closely and firmly united, but in abnormally light seeds they are only slightly united, show considerable air space between them, and are very easily split, which is not the case with good seeds. In one seed of specific gravity 1.001 the cotyledon had not filled the space immediately under the radicle. The whole texture of the cotyledons was soft and they were easily crushed. This is not the case with normally developed seeds. At another time a seed of specific gravity 1.03 was under examination. It was noticed that the cotyledons were loose within the testa; and when the seed was split and one-half of it inverted, the contents fell out of the seed-coat of their own weight. In a seed of normal specific gravity the cotyledon adheres very closely to the seed-coat. In the seed of specific gravity of 1.03, just referred to, the specific gravity of each cotyledon taken singly was about 1.25. Here again is indicated how unreliable an index the apparent specific gravity of the whole seed may be to the specific gravity of the essential parts within.

In the case of cabbage seeds also, differences in specific gravity were found to be correlated with differences in physical character. In a cabbage seed of normal specific gravity the embryo is of a shade of lemon yellow and the cotyledons which surround it are of a slightly greenish hue; but in seeds of very low specific gravity, that is, less than 1.00, this difference in color was not observed to exist. The entire interior of the seed is uniformly yellowish, but of a lighter and more buff-like color than in the plump seed. The light seed is also noticeably drier than the heavy seed and on a casual examination appears to be of a more woody texture; but microscopic examination does not confirm this impression. A seed of very low specific gravity is also not well developed internally, the cotyledons not being in close contact either with the radicle or with the seed-coat. If such a seed is cut in half and inverted the kernel will fall out of the seed-coat. This is not the case with a normal seed.

Extreme differences in specific gravity in the cases of cabbage seed and peas have been shown to be due to the presence of an unusual amount of air within the seed-coat; hence, strictly, the specific gravity of the seed should not be spoken of as affecting its cultural properties. But wherever an unusual amount of air is found within a seed, other characters of the seed are found to be correlated with this condition so that indirectly the specific gravity of the seed is in a general way an index to, though not a measure of, the specific gravity of its essential parts.

To ascertain whether differences in specific gravity obtain among the structural sub-divisions of the essential parts of the seed, examinations were made of squash seeds as material easy of manipulation. Squash seeds in their normal condition are uniformly lighter than water. The outer seed-coats were removed from a number and the specific gravities of the kernels were found to range from 1.03 to 1.08. The radicles are much denser than the cotyledons as appears from the following dissections:

Sp. gr. of cotyledons:	1.05	1.065	1.07	1.08
" " " radicles:	1.105	1.12	1.13	1.135

The cotyledon lowest in density was accompanied by a radicle also lowest in density, and the cotyledon highest in density was accompanied by the radicle highest in density. It appears, then, that the densities of these two structural parts vary together in a general way, that is, apparently the development of these organs and the storage of reserve material within them proceeds together. This general statement is also supported by observations on peas.

The specific gravity of the two cotyledons is the same or practically the same, both in the squash and in the pea, the only kind of seed on which observations have been made on this point by the writer.

The cotyledons are of uniform density throughout, at least in the case of the squash, as may be shown as follows: If a single cotyledon be separated from its radicle and placed in a liquid of such density that it almost remains in suspension, the thinner distal edge comes to the surface first if the cotyledon rises, or remains longest buoyed up in the liquid if the thicker proximal end barely sinks to the bottom. But if the dark covering of the cotyledon be carefully removed all parts of it rise or sink together, showing their equal density, and showing further that this dark covering (the inner seed-coat) is of much less density than the cotyledon itself, which is otherwise obvious. By the same method the difference in density between the cotyledon and the radicle can be shown. This method may also be used in some cases to locate quickly large air spaces if such exist in one part of a seed, as in the grape seed and sweet corn. In the latter case the air spaces are around the embryo.

APPLICABILITY OF THE METHOD OF SEED SELECTION ACCORDING TO SPECIFIC GRAVITY.

The method of separating seeds into a series of separates of approximately uniform densities is of course a method of investigation and not of practice. By means of it, together with culture tests, may be ascertained the limits of specific gravity within which the most desirable seeds for planting are embraced. The practical application of the method consists in making up one or two solutions of predetermined densities and by means of them separating the seeds that are to be planted.

The method of solutions is of only restricted application, but within limits it appears to give promise of considerable usefulness. Specific gravity is of not nearly so great moment in seed selection as is size; but after seeds have been separated into lots of approximately the same size by sifting, then the method of specific gravity carries the selection a step farther. The most desirable method of selecting seeds would be to weigh each individual seed; but this is out of the question in field practice. If seeds were of uniform density, the method of sifting should alone admit of selecting the desirable individuals; but the size does not take into account the density of the seed. These two methods of selection are combined in the fanning-mill method and in the method of seed selection by means of centrifugal force; but on the other hand, neither of these methods admits of exactness of application as does the method of solutions.

Some kinds of seeds do not admit of sifting satisfactorily on account of either small size or irregular shape. To this category belong timothy seed, carrot, tomato, egg-plant and pepper. To such seeds the method of solutions is especially applicable, since various other physical properties of cultural importance are correlated with specific gravity.

The method of solutions is rather unsatisfactory of application to seeds such as oats and lettuce, which have a rough husk-like covering that retains air when the seeds are immersed.

The method does not give so striking results with seeds not having a rigid seed-coat but having relatively large cotyledons, as peas, or having a large quantity of endosperm, as maize, as it does with seeds having a rigid seed-coat, such as grape seed, pepper, egg-plant, etc. In the hands of the writer the method has given no positive results at all with corn or with beans.

Correlations between specific gravity of seed and vigor of the resulting seedling are less close than correlations between the specific gravity of the seed and its germination; nevertheless such correlations do exist, it appears, in sufficient degree to make them of value in practice.

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In this bibliography are comprised such references to the subject of specific gravity of seeds as have come to the writer's attention in the course of a rather limited survey of the literature. They are taken in larger part from the *Samenkunde* of Nobbe and the *Saat und Pflege der landwirtschaftlichen Kulturpflanzen* of Wollny. The subject of specific gravity of seed has been worked up in various monographs, especially in those of Marek and Schertler, as also in the *Samenkunde* of Harz; but to these works the writer has not had access.

Since the manuscript of this bulletin was prepared for the printer the writer has learned that Dr. T. L. Lyon of the Nebraska Experiment Station is about to publish from the Plant Breeding Laboratory of the U. S. Department of Agriculture, a report of extended investigations on the relations between specific gravity and other properties, such as composition and size of grain in wheat kernels. The writer regrets that Dr. Lyon's work has not already appeared so that a review of it might be included in this report.

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REPORT

OF

INSPECTION WORK.

W. H. Jordan, *Director.*
L. L. Van Slyke, *Chemist.*
W. H. Andrews, *Assistant Chemist.*
F. D. Fuller, *Assistant Chemist.*

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REPORT OF INSPECTION WORK.

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE SPRING AND FALL OF 1903.*

W. H. Jordan, L. L. Van Slyke, W. H. Andrews.

SUMMARY.

(1.) Samples Collected. During the year 1903, the Station collected 948 samples of commercial fertilizers, representing 540 different brands. Of these different brands 377 were complete fertilizers; of the others, 70 contained phosphoric acid and potash without nitrogen; 29 contained nitrogen and phosphoric acid without potash; 12 contained nitrogen only; 39 contained phosphoric acid alone; and 12 contained potash salts only.

(2) Nitrogen. The 377 brands of complete fertilizers contained nitrogen varying in amount from 0.14 to 8.32 per ct., and averaging 2.11 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.07 per ct., the guaranteed average being 2.04 per ct., and the average found being 2.11 per ct.

In 262 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 1.50 per ct., and averaging 0.22 per ct.

In 115 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 2.08 per ct., and averaging 0.27 per ct. In 96 cases the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 8.91 per ct. and averaged 1.02 per ct.

(3) Available Phosphoric Acid. The 377 brands of complete fertilizers contained available phosphoric acid varying in amount from 0.06 to 15.50 per ct., and averaging 8.50 per ct. The aver-

*Partial reprint of Bulletin No. 252.

age amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 0.83 per ct., the guaranteed average being 7.67 per ct. and the average found being 8.50 per ct.

In 330 brands of complete fertilizers, the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.01 to 4.04 per ct., and averaging 1.04 per ct.

In 47 brands the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.02 to 11.94 per ct. and averaging 0.85 per ct. In 25 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0 to 11.08 per ct. and averaged 5.40 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.03 to 13.33 per ct. and averaging 4.78 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.23 per ct., the guaranteed average being 4.55 per ct., and the average found being 4.78 per ct.

In 275 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 2.79 per ct., and averaging 0.55 per ct.

In 102 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 4.10 per ct. and averaging 0.54 per ct. In 70 of these cases, the deficiency was less than 0.5 per ct.

In 62 cases among the 377 brands of complete fertilizers the potash was contained in the form of sulphate free from an excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $16 to $60 a ton and averaged $26.60. The retail cost of the separate ingredients unmixed averaged $19.64, or $6.96 less than the selling price.

INTRODUCTION.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the year 1903, the Station's collecting agents visited 203 towns between March 24 and August 28, obtaining 948 samples of commercial fertilizers. These samples represent 540 different brands, the product of 60 different manufacturers, each manufacturer being represented by from one to 180 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid and potash without nitrogen.	Brands containing nitrogen and potash without phosphoric acid.	Brands of complete fertilizers.
12	39	12	29	70	1	377

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected during the year, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	PER CT. GUARANTEED.			PER CT. FOUND.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	
Nitrogen	0.41	8.23	2.04	0.14	8.32	2.11	0.07
Available phosphoric acid	1.50	12.00	7.67	0.06	15.50	8.50	0.83
Insoluble phosphoric acid	——	——	——	0.01	5.84	2.05	——
Potash	0.50	15.00	4.55	0.03	13.33	4.78	0.23
Water-soluble nitrogen gen	——	——	——	0.00	8.91	1.02	——
Water-soluble phosphoric acid	——	——	——	0.00	11.08	5.40	——

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials*, could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March, plus about 20 per ct., in case of goods for which there are wholesale quotations.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1903. Cts. per pound.
Nitrogen in ammonia salts	17½
" in nitrates	15
Organic nitrogen in dry and fine-ground fish, meat and blood and mixed fertilizers	17
" in fine-ground bone and tankage	16½
" in medium bone and tankage	12
Phosphoric acid, water-soluble	4½
" citrate-soluble (reverted)	4
" in fine-ground fish, bone and tankage	4
" in cottonseed meal, castor-pomace and ashes	4
" in coarse fish, bone and tankage	3
" in mixed fertilizers, insoluble in ammonium citrate or water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 17 cents a pound for nitrogen, 4½ cents a pound for water-soluble phosphoric acid, 4 cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4½ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following table:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

Commercial valuation of complete fertilizers.	Selling price of one ton of complete fertilizer.			Average increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$19.64	$16	$60	$26.60	$6.96

COST OF ONE POUND OF PLANT-FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	23.00 cents.
Phosphoric acid (available)............	5.75 cents.
Potash	6.10 cents.

NEW FERTILIZER LAW.

The State legislature amended the fertilizer law in 1899 and attention is called to the principal changes that affect manufacturers and dealers.

(1) All fertilizers selling for *five* dollars or more per ton come under the law.

(2) Every manufacturer, importer, dealer or agent must pay a license fee amounting to *twenty* dollars a year for each separate brand or kind of fertilizer or fertilizing material.

(3) Statements of guarantee analysis, etc., are to be filed and license fees paid *during December* each year covering the goods to be sold during the year following.

LIST OF MANUFACTURERS WHO HAVE PAID LICENSE FEES AND FILED STATEMENTS AS REQUIRED BY LAW FOR 1903.

Manufacturers to the number of 87 have, since the first of December, 1902, paid license fees and filed statements in compliance with the provisions of the law. Of these there are 40 firms whose places of business are located outside of New York State. These 87 manufacturers put on the market 646 different brands of fertilizers, including mixed and unmixed goods.

NAMES AND ADDRESSES OF MANUFACTURERS.

	Number of brands reported.
The Abbott-Martin Rendering Co., 16 E. Broad St., Columbus, Ohio	6
The American Agricultural Chemical Co., 26 Broadway, New York City	211
Armour Fertilizer Works, 205 La Salle St., Chicago, Ill.	23
E. Aspinall, 100 Beekman St., New York City	3
A. M. Baker & Son, Mt. Morris, N. Y.	1
Baugh & Sons Co., 20 S. Delaware Ave., Philadelphia, Pa.	3
Berg Co., Station E, Philadelphia, Pa.	3
Berkshire Fertilizer Co., Bridgeport, Conn.	
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	29
Bradley & Green Fertilizer Co., 9th and Girard Aves., Philadelphia, Pa.	3
M. A. Briggs Fertilizer Co., Homer, N. Y.	2
Bucyrus Fertilizer Co., Bucyrus, O.	6
J. P. Butts, Oneonta, N. Y.	
Chicago Fertilizer Co., Security Bldg., Chicago, Ill.	5
The Cincinnati Phosphate Co., Station P., Cincinnati, O.	4
O. W. Clark & Son, 59 Seneca St., Buffalo, N. Y.	1
E. Frank Coe Co., 135 Front St., New York City	39
Peter Cooper's Glue Factory, 13 Burling Slip, New York City	1
G. & W. H. Corson, Plymouth Meeting, Montgomery Co., Pa.	1
Mrs. R. W. Day, Arlington, N. Y.	1
Eagle Guano Co., 19 Liberty St., New York City	1
Farmers Fertilizer and Chemical Co., Syracuse, N. Y.	7
John Finster, Rome, N. Y.	1

	Number of brands reported.
The Fisheries Co., 135 Front St., New York City	2
Henry Fitchard, Minetto, N. Y	1
Flower City Plant Food Co., Rochester, N. Y	2
Geo. B. Forrester, 159 Front St., New York City	1
Henry S. Foster, Tonawanda, N. Y	1
Chas. E. Giles, Apalachin, N. Y	1
Griffith & Boyd, 9 S. Gay St., Baltimore, Md	9
John Haefele, Delaware Ave., Albany, N. Y	1
Hammond's Slug-Shot Works, Fishkill Landing, N. Y	1
F. E. Hancock, Walkerton, Ontario, Can	1
S. M. Hess & Bro., 4th and Chestnut Sts., Philadelphia, Pa	13
International Seed Co., Rochester, N. Y	4
Jarecki Chemical Co., Sandusky, Ohio	10
John Joynt, Lucknow, Ont., Can	1
Lackawanna Fertilizer and Chemical Co., Moosic, Pa	10
Listers' Agricultural Chemical Works, Newark, N. J	21
F. Ludlam, 108 Water St., New York City	9
Mapes Formula and Peruvian Guano Co., 143 Liberty St., New York City	22
The D. B. Martin Co., Land Title Bldg., Philadelphia, Pa	2
Maxson & Starin, Cortland, N. Y	2
McCoy & Best, Peekskill, N. Y	1
Michigan Carbon Works, Detroit, Mich	6
Miller Fertilizer Co., 106 South Gay St., Baltimore, Md	1
L. Mittenmaier & Son, Rome, N. Y	6
Moller & Co., Maspeth, L. I	2
E. Mortimer & Co., 13 William St., New York City	5
Geo. L. Monroe, Oswego, N. Y	1
Nassau Fertilizer Co., 5 Beaver St., New York City	10
National Fertilizer Co., Bridgeport, Conn	3
Newburgh Rendering Co., Newburgh, N. Y	1
Newport Fertilizer Co., 401 Drexel Bldg., Philadelphia, Pa	4
Norton & Colson, Byron, N. Y	7
Ohio Farmers' Fertilizer Co., Hayden Bldg., Columbus, Ohio.	8
Patapsco Guano Co., Box 213, Baltimore, Md	10
A. Peterson, Penfield, N. Y	1
Wm. W. Phipps, Albion, N. Y	3

	Number of brands reported.
Piedmont-Mt. Airy Guano Co., 109 Commerce St., Baltimore, Md.	2
Wilcox Fertilizer Works, Mystic, Conn.	1
B. J. Pine, East Williston, N. Y.	3
The Pollock Fertilizer Co., 51 S. Gay St., Baltimore, Md.	6
Rasin-Monumental Co., Continental Trust Bldg., Baltimore, Md.	9
R. C. Reeves, 187 Water St., New York City	1
James L. Reynolds, New Rochelle, N. Y.	2
George Ripperger, Long Island City	1
Rochester Fertilizer Works, 509 Cox Bldg., Rochester, N. Y.	10
Russia Cement Co., Gloucester, Mass.	6
Sanderson Fertilizer Co., New Haven, Conn.	3
Schaal-Sheldon Fertilizer Co., Erie, Pa.	12
M. L. Shoemaker & Co., Philadelphia, Pa.	1
Chas. C. Schader, Martville, N. Y.	1
Chas. D. Smith, 2 Borden Ave., Long Island City	1
Elmer E. Smith, Wurtsboro, N. Y.	1
Frank B. Smith, Columbiaville, N. Y.	1
H. Stappenbeck, Utica, N. Y.	3
Geo. Stevens, Peterborough, Ont., Can.	1
Swift & Co., Union Stock Yards, Chicago, Ill.	1
Swifts' Lowell Fertilizer Co., 44 N. Market St., Boston, Mass.	8
Syracuse Reduction Co., Syracuse, N. Y.	5
I. P. Thomas & Son Co., 2. S. Delaware Ave., Philadelphia, Pa.	6
J. M. Thorburn & Co., 36 Cortlandt St., New York City	3
Tuscarora Fertilizer Co., Box 184, Chicago, Ill.	11
J. E. Tygert Co., 42 S. Delaware Ave., Philadelphia, Pa.	3
Walbridge & Co., 392 Main St., Buffalo, N. Y.	1
W. E. Whann, William Penn, Pa.	3
Wilcox Fertilizer Works, Mystic, Conn.	1

[The analyses of samples collected, as given in the bulletin, are not reprinted here, as they cease to have value before this Report is distributed.—DIRECTOR.]

REPORT OF ANALYSES OF COMMERCIAL FERTILIZERS FOR THE SPRING OF 1904.*

W. H. Jordan, L. L. Van Slyke and W. H. Andrews.

SUMMARY.

(1) Samples Collected. During the spring of 1904, the Station collected 468 samples of commercial fertilizers, representing 371 different brands. Of these different brands 275 were complete fertilizers; of the others, 47 contained phosphoric acid and potash without nitrogen; 16 contained nitrogen and phosphoric acid without potash; 7 contained nitrogen only; 22 contained phosphoric acid alone; and 4 contained potash salts only.

(2) Nitrogen. The 275 brands of complete fertilizers contained nitrogen varying in amount from 0.54 to 9.74 per ct., and averaging 2.12 per ct. The average amount of nitrogen found by the Station analysis exceeded the average guaranteed amount by 0.11 per ct., the guaranteed average being 2.01 per ct., and the average found being 2.12 per ct.

In 194 brands of complete fertilizers, the amount of nitrogen found was equal to or above the guaranteed amount, the excess varying from 0.01 to 1.78 per ct., and averaging 0.22 per ct.

In 81 brands the nitrogen was below the guaranteed amount, the deficiency varying from 0.01 to 1.04 per ct., and averaging 0.17 per ct. In 77 cases the deficiency was less than 0.5 per ct.

The amount of water-soluble nitrogen varied from 0 to 9.62 per ct. and averaged 1.01 per ct.

(3) Available Phosphoric Acid. The 275 brands of complete fertilizers contained available phosphoric acid varying in amount from 1.26 to 11.38 per ct., and averaging 8.52 per ct. The average amount of available phosphoric acid found by the Station analysis exceeded the average guaranteed amount by 0.96 per ct., the guaranteed average being 7.56 per ct., and the average found being 8.52 per ct.

*Partial reprint of Bulletin No. 253.

In 246 brands of complete fertilizers, the amount of available phosphoric acid found was equal to or above the amount guaranteed, the excess varying from 0.02 to 3.38 per ct., and averaging 1.06 per ct.

In 29 brands the available phosphoric acid was below the guaranteed amount, the deficiency varying from 0.04 to 4.20 per ct., and averaging 0.84 per ct. In 14 cases the deficiency was below 0.5 per ct.

The amount of water-soluble phosphoric acid varied from 0.04 to 8.96 per ct. and averaged 5.98 per ct.

(4) Potash. The complete fertilizers contained potash varying in amount from 0.16 to 10.74 per ct. and averaging 4.77 per ct. The average amount of potash found by the Station analysis exceeded the average guaranteed amount by 0.27 per ct., the guaranteed average being 4.50 per ct., and the average found being 4.77 per ct.

In 200 brands of complete fertilizers, the amount of potash found was equal to or above the guaranteed amount, the excess varying from 0.01 to 3.25 per ct., and averaging 0.51 per ct.

In 75 brands, the potash was below the guaranteed amount, the deficiency varying from 0.01 to 2.42 per ct., and averaging 0.45 per ct. In 53 of these cases, the deficiency was less than 0.5 per ct.

In 45 cases among the 275 brands of complete fertilizers the potash was contained in the form of sulphate free from excess of chlorides.

(5) The retail selling price of the complete fertilizers varied from $17 to $45 a ton and averaged $27.56.

The retail cost of the separate ingredients unmixed averaged $19.85, or $7.71 less than the selling price.

INTRODUCTION.

In May of this current year, an amendment to the fertilizer law of this State was made by the legislature, as a result of which the administration of the law was transferred to the Department of Agriculture. This Station continues to perform the chemical analyses. The analyses published in this bulletin represent only samples of fertilizers collected by this Station previous to the time the law was amended in May.

NUMBER AND KINDS OF FERTILIZERS COLLECTED.

During the spring of 1904, the Station's collecting agents visited 98 towns between March 26 and May 9, obtaining 468 samples of commercial fertilizers. These samples represent 371 different brands, the product of 49 different manufacturers, each manufacturer being represented by from one to 145 brands.

The subjoined tabulated statement indicates the different classes included in the collection.

CLASSES OF FERTILIZERS COLLECTED.

Brands containing only nitrogen.	Brands containing only phosphoric acid.	Brands containing only potash.	Brands containing nitrogen and phosphoric acid without potash.	Brands containing phosphoric acid and potash without nitrogen.	Brands of complete fertilizers.
7	22	4	16	47	275

COMPOSITION OF FERTILIZERS COLLECTED.

The following tabulated statement shows the average composition of the complete fertilizers collected, together with a comparison of the guaranteed composition and that found by analysis.

AVERAGE COMPOSITION OF COMPLETE FERTILIZERS COLLECTED.

	PER CENT. GUARANTEED.			PER CENT. FOUND.			Average per ct. found above guarantee.
	Lowest.	Highest.	Average.	Lowest.	Highest.	Average.	
Nitrogen	0.50	9.88	2.01	0.54	9.74	2.12	0.11
Available phosphoric acid	1.50	10.00	7.56	1.26	11.38	8.52	0.90
Insoluble phosphoric acid	———	———	———	0.04	6.52	1.80	———
Potash	0.50	10.00	4.50	0.16	10.74	4.77	0.27
Water soluble nitrogen	———	———	———	0.00	9.62	1.01	———
Water-soluble phosphoric acid	———	———	———	0.04	8.96	5.98	———

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

The trade-values in the following schedule have been agreed upon by the Experiment Stations of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Vermont, as a result of study of the prices actually prevailing in the large markets of these states.

These trade-values represent, as nearly as can be estimated, the average prices at which, during the six months preceding March, the respective ingredients, *in the form of unmixed raw materials,* could be bought at retail for cash in our large markets. These prices also correspond (except in case of available phosphoric acid) to the average wholesale prices for the six months preceding March, plus about 20 per ct., in case of goods for which there are wholesale quotations.

TRADE-VALUES OF PLANT-FOOD ELEMENTS IN RAW MATERIALS AND CHEMICALS.

	1903. Cents per pound.
Nitrogen in ammonia salts	17½
" in nitrates	16
Organic nitrogen in dry and fine-ground fish, meat and blood and mixed fertilizers	17½
" in fine-ground bone and tankage	7
" in medium bone and tankage	12½
Phosphoric acid, water-soluble	4½
" citrate-soluble (reverted)	4
" in fine-ground fish, bone and tankage,	4
" in cottonseed meal, caster-pomace and ashes	4
" in coarse fish, bone and tankage	3
" in mixed fertilizers, insoluble in ammonium citrate of water	2
Potash as high-grade sulphate, in forms free from muriates (chlorides), in ashes, etc	5
Potash in muriate	4¼

COMPARISON OF SELLING PRICE AND COMMERCIAL VALUATION.

Giving to the different constituents the values assigned in the schedule for mixed fertilizers, 17½ cents a pound for nitrogen, 4½ cents a pound for water-soluble phosphoric acid, 4 cents a pound for citrate-soluble phosphoric acid, 2 cents a pound for insoluble phosphoric acid, and 4½ cents a pound for potash, we can calculate the commercial valuation, or the price at which the separate unmixed materials contained in one ton of fertilizer, having the composition indicated in the preceding table, could be purchased for cash at retail at the seaboard. Knowing the retail prices at which these goods were offered for sale, we can also readily estimate the difference between the actual selling price of the mixed goods and the retail cash cost of the unmixed materials; the difference covers the cost of mixing, freight, profits, etc. We present these data in the following table:

COMMERCIAL VALUATION AND SELLING PRICE OF COMPLETE FERTILIZERS.

COMMERCIAL VALUATION OF COMPLETE FERTILIZERS.	SELLING PRICE OF ONE TON OF COMPLETE FERTILIZER.			Average increased cost of mixed materials over unmixed materials for one ton.
Average.	Lowest.	Highest.	Average.	
$19.85	$17	$45	$27 56	$7 71

COST OF ONE POUND OF PLANT-FOOD IN FERTILIZERS AS PURCHASED BY CONSUMERS.

In the table below we present figures showing the average cost to the purchaser of one pound of plant-food in different forms in mixed fertilizers.

AVERAGE COST OF ONE POUND OF PLANT-FOOD TO CONSUMERS IN MIXED FERTILIZERS.

Nitrogen	24.30 cents.
Phosphoric acid (available)	5.90 cents.
Potash	6.25 cents.

LIST OF MANUFACTURERS WHO HAVE PAID LICENSE FEES AND FILED STATEMENTS.

Manufacturers to the number of 70 have, since the first of December, and up to May 14th, 1904, paid license fees and filed statements in compliance with the provisions of the law. These manufacturers put on the market 585 different brands of fertilizers, including mixed and unmixed goods.

NAMES AND ADDRESSES OF MANUFACTURERS.

	Number of brands reported.
The Abbott-Martin Rendering Co., 16 E. Broad St., Columbus, Ohio	2
The American Agricultural Chemical Co., 26 Broadway, New York City	216
Armour Fertilizer Works, 205 La Salle St., Chicago, Ill.	20
E. Aspinall, 100 Beekman St., New York City	2
Berg Co., Station E, Philadelphia, Pa	3
Berkshire Fertilizer Co., Bridgeport, Conn	3
Bowker Fertilizer Co., 43 Chatham St., Boston, Mass.	29
Bradley & Green Fertilizer Co., 9th and Girard Aves., Philadelphia, Pa	3
Buffalo Fertilizer Co., Buffalo, N. Y	18
J. P. Butts, Oneonta, N. Y	3
Chicago Fertilizer Co., Security Bldg., Chicago, Ill	2
The Cincinnati Phosphate Co., Station P, Cincinnati, O.	4
O. W. Clark & Son, 59 Seneca St., Buffalo, N. Y	1
E. Frank Coe Co., 135 Front St., New York City	34
Peter Cooper's Glue Factory, 13 Burling Slip, New York City	1
G. & W. H. Corson, Plymouth Meeting, Montgomery Co., Pa	2
Mrs. R. W. Day, Arlington, N. Y	1
Eagle Guano Co., 19 Liberty St., New York City	1
John Finster, Rome, N. Y	1
The Fisheries Co., 135 Front St., New York City	2
George B. Forrester, 159 Front St., New York City	1
Henry S. Foster, Tonawanda, N. Y	1
Griffith & Boyd, 9 S. Gay St., Baltimore, Md	6
Hammond's Slug-Shot Works, Fishkill Landing, N. Y.	1
S. M. Hess & Bro., 4th and Chestnut Sts., Philadelphia, Pa.,	14
L. T. Huber, Lockport, N. Y	1
International Seed Co., Rochester, N. Y	4
Jarecki Chemical Co., Sandusky, Ohio	11
John Joynt, Lucknow, Ont., Can	1
The N. Lawrence Co., Dobbs Ferry, N. Y	2
Listers' Agricultural Chemical Works, Newark, N. J.	21

	Number of brands reported.
F. Ludlam, 108 Water St., New York City...............	9
Mapes Formula and Peruvian Guano Co., 143 Liberty St., New York City..................................	22
The D. B. Martin Co., Land Title Bldg., Philadelphia, Pa..	1
Maxson & Starin, Cortland, N. Y......................	2
McCoy & Best, Peekskill, N. Y........................	1
Michigan Carbon Works, Detroit, Mich.................	6
Miller Fertilizer Co., 106 South Gay St., Baltimore, Md..	1
L. Mittenmaier & Son, Rome, N. Y....................	6
Moller & Co., Maspeth, L. I..........................	2
E. Mortimer & Co., 13 William St., New York City........	2
Geo. L. Munroe, Oswego, N. Y.........................	1
Nassau Fertilizer Co., 5 Beaver St., New York City......	12
National Fertilizer Co., Bridgeport, Conn...............	3
Newburgh Rendering Co., Newburgh, N. Y...............	1
Norton & Colson, Byron, N. Y.........................	7
Ohio Farmers' Fertilizer Co., Hayden Bldg., Columbus, O.,	2
A. Peterson, Penfield, N. Y............................	1
Wm. W. Phipps, Albion, N. Y.........................	3
B. J. Pine, East Williston, N. Y.......................	2
Rasin Monumental Co., Continental Trust Bldg., Baltimore, Md	7
R. C. Reeves, 187 Water St., New York City.............	1
J. G. Reichard & Bro., Middletown, N. Y...............	3
James L. Reynolds, New Rochelle, N. Y................	2
George Ripperger, Long Island City....................	1
Russia Cement Co., Gloucester, Mass....................	6
Sanderson Fertilizer Co., New Haven, Conn.............	3
Schaal-Sheldon Fertilizer Co., Erie, Pa.................	8
M. L. Shoemaker & Co., Philadelphia, Pa...............	2
Chas. C. Schader, Martville, N. Y......................	1
Frank B. Smith, Columbiaville, N. Y...................	1
H. Stappenbeck, Utica, N. Y..........................	3
Swift & Co., Union Stock Yards, Chicago, Ill............	5
Swifts' Lowell Fertilizer Co., 44 N. Market St., Boston, Mass	7
I. P. Thomas & Son Co., 2 So. Delaware Ave., Philadelphia, Pa	6

	Number of brands reported.
J. M. Thorburn & Co., 36 Cortlandt St., New York City..	2
Tuscarora Fertilizer Co., Box 184, Chicago, Ill..........	15
J. E. Tygert Co., 42 So. Delaware Ave., Philadelphia, Pa..	5
W. E. Whann, William Penn, Pa......................	4
Wilcox Fertilizer Works, Mystic, Conn.................	1

[The analyses of samples collected, as given in the bulletin, are not reprinted here, as they cease to have value before this Report is distributed.—DIRECTOR.]

INSPECTION OF FEEDING STUFFS.*

W. H. Jordan and F. D. Fuller.

SUMMARY.

(1) Prior to May 3d 104 manufacturers licensed 154 brands of feeding stuffs for the year 1904.

(2) 263 samples of feed stuffs, officially collected from Jan. 6, 1904, to May 6. 1904, have been analyzed.

INTRODUCTION.

Herewith is presented the work of the Station in the examination of concentrated feeding stuffs found in the markets of New York State, in 1904, in compliance with the provisions of the Agricultural Law, Chap. 338, Article 9.

The law under which the samples included in this bulletin were taken so defined the term "concentrated commercial feeding stuffs" that it practically covered all feeds *excepting the following:*—Hays and straws, and the *entire* grains of wheat, rye, barley, oats, maize (corn), buckwheat and broom corn, either whole or ground into meal; also bran and middlings from wheat, rye and buckwheat when sold as such unmixed with other materials. The above feeds may still be sold legally without the payment of a license fee.

AMENDMENT OF THE LAW.

The Legislature of 1904 passed an act amending the law controlling the sale and analysis of concentrated commercial feeding stuffs, which was approved by the Governor on May 3d, 1904. This amendment transfers the administration of the feeding stuffs law to the Commissioner of Agriculture, the Experiment Station still being required to analyze the samples of feeding stuffs collected by said Commissioner. Certain materials were added to the specified list of feeds which are defined as "concen-

*Reprint of Bulletin No. 255.

trated commercial feeding stuffs," as follows: bean meals, peanut meals, dried distillers' grains, dried beet refuse, meat and bone meals, clover meals, condimental stock and poultry foods, patented and proprietary, or trade-marked, stock and poultry foods.

The condimental stock and poultry foods were added to the list of feeding stuffs requiring legal supervision because it was felt that the interests of the agricultural public demand this. If these mixtures were offered to the public merely as medicines or condiments and no other claims were made for them they would not properly be classed among feeding stuffs. The fact is, however, in a large number of cases extraordinary and even startling claims are made as to the nutritive (food) value of these substances, and it is but just that these claims should be subject to the same examination given to other materials offered to the public as food for cattle. It is time for the public to be more fully defended, if possible, against what is now one of the most serious impositions practiced upon it.

The law has been further modified by repealing section 127 which required that any person violating the provisions of the law be given thirty days after one notice in which to comply with said provisions. The actual effect of this requirement, under the interpretation placed upon section 127 by the Attorney-General, was to prevent prosecutions of offenders, a fact which caused the attitude of the Director of the Station to be misinterpreted by those ignorant of the situation.

FEEDING STUFFS LICENSED IN 1904.

Previous to May 3d, 1904, 104 manufacturers or jobbers registered the required guarantees and paid the license fee on 154 brands of feeding stuffs to be placed on sale in New York State in 1904.

The brands named in the following table (1) may be handled legally during the current year:

TABLE I.—MANUFACTURERS AND JOBBERS WHO, PRIOR TO MAY 3D, 1904, COMPLIED WITH THE NEW YORK FEEDING STUFFS LAW FOR THE YEAR 1904, WITH A LIST OF BRANDS SO GUARANTEED AND THE GUARANTEES.

License number.	Manufacturer or Jobber.		Name of feed.	Guarantees.	
	Name.	Address.		Protein.	Fat.
				Per ct.	*Per ct.*
421	Acme Milling Co.	Olean	Acme feed	8.5	4.5
464	Adikes, J. & T.	Jamaica	Ground feed	8.75	3.0
411	American Cereal Co., The	Chicago, Ill	American poultry food	14.0	4.5
	American Cereal Co., The	Chicago, Ill	Quaker dairy feed	14.0	3.5
	American Cereal Co., The	Chicago, Ill	Corn, oats and barley feed	13.0	5.0
	American Cereal Co., The	Chicago, Ill	Schumacher's stock food	13.0	5.0
	American Cereal Co., The	Chicago, Ill	"C" feed	9.0	4.0
	American Cereal Co., The	Chicago, Ill	Victor corn and oat feed	9.0	4.0
	American Cereal Co., The	Chicago, Ill	Vim oat feed	7.5	2.75
472	American Cotton Oil Co., The	New York	Prime cottonseed meal	43.0	9.0
394	American Hominy Co.	Indianapolis, Ind	Maizeline	14.81	8.76
	American Hominy Co.	Indianapolis, Ind	Hominy feed	10.24	7.72
438	American Linseed Co.	New York	Oil meal, O. P.	32–36	5.7
420	American Malting Co.	New York	Malt sprouts	25.0	2.0
453	American Milling Co.	Peoria, Ill	Sucrene dairy feed	16.5	3.5
	American Milling Co.	Peoria, Ill	Sucrene horse feed	13.5	5.0
432	Armour Fertilizer Works, The	Chicago, Ill	Blood meal	87.0	0.2
	Armour Fertilizer Works, The	Chicago, Ill	Meat meal	50.0	10.0
	Armour Fertilizer Works, The	Chicago, Ill	Meat and bone	45.0	8.0
	Armour Fertilizer Works, The	Chicago, Ill	Poultry bone	25.0	5.0
433	Bagley, G. A.	Peekskill	G. W. Bagley & Son's mixed feed	16.0	6.0
488	Baringer, M. F.	Philadelphia, Pa	No. 100 fancy white corn bran	11.0	7.22
413	Bartholomay Brewery Co.	Rochester	Malt-sprouts	30.74	0.32
451	Barwell, J. W.	Waukegan, Ill	Blatchford's calf meal	25.0	5.0
	Barwell, J. W.	Waukegan, Ill	Blatchford's sugar and flaxseed	28.25	11.25
460	Berg Co., The	Philadelphia, Pa	Berg's 3 medal poultry meat	50–55	13–15
401	Biles, J. W., Co., The	Cincinnati, O.	Biles' fourex (XXXX) distillers' dried grains	33.0	11.0
	Biles, J. W., Co., The	Cincinnati, O.	Biles' ready ration, union grains	24.0	7.0
449	Biles, J. W., Co., The	Cincinnati, O.	Biles' rye (R) distillers' dried grains	21.0	5.0
444	Blomo Manufacturing Co.	New York	Blomo feed	15.0	1.19
457	Bowker Fertilizer Co.	New York	Bowker's beef scraps	30.0	20.0
	Bowker Fertilizer Co.	New York	Bowker's animal meal	30.0	5.0
469	Brode, F. W., & Co.	Memphis, Tenn	"Owl" cottonseed meal	43.0	9.0
467	Brooks Elevator Co.	Minneapolis, Minn	Royal mixed feed	16.61	5.48

TABLE I.—*Continued.*

License number.	Manufacturer or Jobber.		Name of feed.	Guarantees.	
	Name.	Address.		Protein.	Fat.
				Per ct.	*Per ct.*
443	Buffalo Cereal Co.	Buffalo	Creamery feed	20.0	5.0
	Buffalo Cereal Co.	Buffalo	Poultry feed	17.0	5.0
	Buffalo Cereal Co.	Buffalo	Dairy feed	14.0	4.0
	Buffalo Cereal Co.	Buffalo	Horse feed	12.0	4.5
	Buffalo Cereal Co.	Buffalo	Hominy feed	10.5	8.5
	Buffalo Cereal Co.	Buffalo	3 X stock feed	9.0	4.5
459	Buffalo Cereal Co.	Buffalo	Howard's hominy meal	10.5	8.5
395	Cassel, F. P.	Lansdale, Pa.	F. P. C. chick manna	14.01	4.75
416	Chapin & Co.	Buffalo	Green diamond cottonseed meal	43.0	9.0
446	Clark & Mercer	Baldwinsville	Meal and shorts	12.05	4.15
492	Clements, A. L., & Co.	New York	C. C. C. cow oil meal	32–38	5–8
408	Commercial Milling Co.	Detroit, Mich.	Dandy corn and oat chop feed	10.81	6.02
499	Continental Cereal Co.	Peoria, Ill.	Continental gluten feed	35.0	12.5
415	Coonley, G. W.	Albany	Capitol C. & O. feed	9.04	3.75
397	Crow & Williams	Ossining	C & W. mixed feed	10.0	4.0
435	Curtiss Co., C. G., The	Buffalo	Malt sprouts	25.0	1.0
485	Cyphers Incubator Co.	Buffalo	Cyphers laying food	15.26	5.5
498	Cyphers Incubator Co.	Buffalo	Cyphers forcing food	18.17	7.11
389	Darling & Co.	Chicago, Ill.	Beef scraps	55–65	10–15
	Darling & Co.	Chicago, Ill.	Beef meal	45–55	10–15
465	Dewey Bros. Co., The	Blanchester, O.	Corn protegran	33.0	8.5
473	Diamond Elevator & Milling Co.	Minneapolis, Minn.	"O. O." feed	9.19	6.85
494	Dixon & Warren	Port Bryon	Provender	9.4	3.85
462	Ellicottville Milling Co.	Ellicottville	Chop feed	8.2	4.4
402	Empire Mills	Olean	Empire feed	7.63	2.97
412	Everett & Treadwell	Kingston	C. O. & W. feed	11.5	3.5
392	Finn, G. M.	Syracuse	Ground beef and bone scraps	40–45	18–20
409	Flint Mill Co.	Buffalo	Green oval linseed meal	32–36	5–7
	Flint Mill Co.	Buffalo	Flint gluten feed	28.5	3.0
	Flint Mill Co.	Buffalo	Apex stock food	16.0	4.7
	Flint Mill Co.	Buffalo	Green diamond hominy feed	11.0	8–9
441	Glucose Sugar Refining Co., The	Chicago, Ill.	Chicago gluten meal	37.0	3.0

441	Glucose Sugar Refining Co., The	Chicago, Ill.	Buffalo gluten feed	27.0	3.0
	Glucose Sugar Refining Co., The	Chicago, Ill.	Germ oil meal	22.0	10.0
	Glucose Sugar Refining Co., The	Chicago, Ill.	Fancy corn bran	14.0	3.0
491	Grandin, D. H.	Jamestown	Chautauqua chop feed	8.09	4.16
393	Great Western Cereal Co., The	Chicago, Ill.	Excelsior C. & O. feed	9.0	4.2
	Great Western Cereal Co., The	Chicago, Ill.	Boss C. & O. feed	9.0	4.0
	Great Western Cereal Co., The	Chicago, Ill.	Friends' oat feed	8.0	3.0
	Great Western Cereal Co., The	Chicago, Ill.	Royal oat feed	7.6	2.8
495	Great Western Cereal Co., The	Chicago, Ill.	Derby hominy feed	11.0	8.0
463	Harding, G. L.	Binghamton	Meat meal	55.0	10.0
	Harding, G. L.	Binghamton	Beef scraps	45.0	25.0
	Harding, G. L.	Binghamton	Egg builder ration	20.0	5.0
430	Hauenstein & Co.	Buffalo	Linseed meal, O. P.	35.65	7.62
471	Hayt, S. T.	Corning	Corn and oat feed	10.43	4.0
484	H-O Company, The	Buffalo	The H-O Co.'s dairy feed	18.0	4.5
	H-O Company, The	Buffalo,	The H-O Co.'s poultry feed	17.0	5.5
	H-O Company, The	Buffalo	The H-O Co.'s horse feed	12.0	4.5
	H-O Company, The	Buffalo	Edw. Elsworth & Co.'s de-fi corn and oat feed	8.03	3.0
474	Hodgman Milling Co.	Painted Post	Corn and oat chop feed	9.69	3.88
470	Hotton, Nicholas	Portville	Common feed	8.38	4.85
482	Hubinger, J. C., Bros. Co.	Keokuk, Ia.	K. K. K. gluten feed	27.0	3.0
404	Hunter Bros. Milling Co., The	St. Louis, Mo.	Hominy feed	11.02	7.7
486	Hunter Bros. Milling Co., The	St. Louis, Mo.	Cottonseed meal	43.0	9.0
476	Hunter Bros. Milling Co., The	St. Louis, Mo.	Linseed oil meal, O. P.	34.0	6.5
399	Husted Milling and Elevator Co.	Buffalo	Monarch chop	8.09	4.16
407	Hygienic Food Co.	Buffalo	Hygienic stock food	11.56	3.62
437	Illinois Sugar Refining Co.	Chicago, Ill.	Cream gluten meal	37.0	3.0
	Illinois Sugar Refining Co.	Chicago, Ill.	Pekin gluten feed	27.0	3.0
	Illinois Sugar Refining Co.	Chicago, Ill.	Geneva corn bran	11.0	3.0
483	Iowa Milling Co.	Davenport, Ia.	Hawkeye gluten feed	25.18	5.92
387	Kam Malting Co.	Buffalo	Malt sprouts	23.81	1.34
427	Kellogg, Spencer	Buffalo	"S. K." oil meal, O. P.	35.94	5.04
391	Kelloggs & Miller	Amsterdam	Pure oil meal, O. P.	36.7	7.83
450	Kidder, F. L., & Co.	Paris, Ill.	Kidder's feed	11.0	8.05
458	Knickerbocker Milling & Grain Co.	Albany	Champion feed	9.92	4.01
461	Krause, C. A., Grain Co.	Milwaukee, Wis.	Blue ribbon corn distillers' grains	33.0	11.0
497	Lackawanna Mill & Elevator Co.	Buffalo	Lackawanna special horse and cattle feed	10.93	3.48
456	Lapham & Parks	Glens Falls	Common feed	7.5	3.2
493	Larrowe Milling Co., The	New York	Dried molasses beet pulp	9.63	0.42
	Larrowe Milling Co., The	New York	Dried beet pulp	8.56	0.59
478	Lawrence, N., Co., The	Dobbs Ferry	Dandy dairy feed	8.0	2.5
398	Mann Bros. Co., The	Buffalo	Linseed oil meal	35.15	6.05
424	Marcus, Julius	New York	Manhattan gluten feed	32–35	10–12
425	Marcus, Julius	New York	Merchants' dairy feed	32–35	10.8–12.0

TABLE I.—*Concluded.*

License number.	Manufacturer or Jobber.		Name of feed.	Guarantees.	
	Name.	Address.		Protein.	Fat.
				Per ct.	Per ct.
426	Marcus, Julius	New York	Ajax flakes	32-35	10.8-12.0
440	McCoy & Best	Peekskill	Evaporated bone and meat meal	41.4	19.75
396	Metzger Seed & Oil Co	Toledo, O	Oil meal, O. P	30-36	5-7
423	Meurer, Deutsch & Sickert Co	Milwaukee, Wis	Climax grains	34.0	11.0
496	Michigan Starch Co., The	New York	Michigan gluten feed	27.0	4.0
414	Midland Linseed Co	Minneapolis, Minn	Ground linseed cake, O. P	32.5-37.5	5.5-8.5
436	National Starch Co	Chicago, Ill	Queen gluten feed	26.0	3.0
418	Nester, S. K	Geneva	Malt sprouts	25.0	2.0
428	Niagara Mill & Elevator Co	Buffalo	Niagara C. & O. feed	8.2	3.37
481	Noblesville Milling Co	Noblesville, Ind	N. M. Co.'s hominy chop	{10.25 / 11.0}	7.7-8.0
403	N. Y. Glucose Co	New York	Globe gluten feed	27.0	3.0
390	Oliver, Geo	Olean	Chop feed	8.58	4.86
388	Oliver Refining Co	Portsmouth, Va	Cottonseed meal	43.0	9.0
	Oliver Refining Co	Portsmouth, Va	Cottonseed feed	10.0	3.0
405	Oneonta Milling Co	Albany	Monarch horse feed	13.0	5.75
	Oneonta Milling Co	Albany	Corn and oat provender	8.75	3.5
429	Oneonta Milling Co	Albany	Arrow corn and oat feed	9.0	3.75
468	Page, J. D., & Co	Syracuse	Empire State dairy feed	36.22	11.76
455	Patent Cereals Co., The	Geneva	Hominy feed	11.0	8.0
490	Payne, W. H., & Son	New York	Hominy chop	11.49	8.0
480	Petitt, Hugh, & Co	Memphis, Tenn	Horseshoe cottonseed meal	43-47	9-11
466	Pfeffer Milling Co	Lebanon, Ill	Pfeffer Milling Co.'s hominy feed	10.0	8.0
386	Piel Bros. Starch Co	Indianapolis, Ind	Piel Bros.' gluten feed	27.6	2.6
447	Pratt Cereal Oil Co	Decatur, Ill	Germaline	12.9	1.29
487	Puritan Poultry Farms & Mfg. Co	Stamford, Conn	Puritan chick food	12.5	7.5
489	Rodebaugh, J. H	Buffalo	Stone Mills mixed feed	12.59	3.19
431	Romaine, DeWitt	New York	Boiled beef and bone	45.0	15.0
475	Smith, A. V	Marcellus Falls	Barley meal	14.8	3.4
479	Stanton, H. M	Schenectady	Ground scraps	50.0	9.0
445	Staples, A. S	Rondout	Arcade mixed feed	10.42	5.86
439	Streeter, L. L., & Sons	Johnstown	Common feed	8.78	5.23
417	Suffern, Hunt & Co	Decatur, Ill	Hominy feed	11.02	7.7

442	Swift's Lowell Fertilizer Co.	Boston, Mass.	Swift's Lowell bone and meat meal	40–50	8–15
400	Toledo Elevator Co., The	Toledo, O.	Regular hominy	12.6	8.57
	Toledo Elevator Co., The	Toledo, O.	Star feed	11.4	7.31
434	Union Linseed Co.	Troy	"Cow" oil meal	22.09	6.32
410	U. S. Frumentum Co.	Detroit, Mich.	Frumentum hominy feed	10.31	7.98
452	Victor Mills	Springville	Golden chop	9.17	5.84
448	Wagar, C. W., & Co.	Philadelphia, Pa.	Cedar Rapids gluten feed	26.57	3.33
	Wagar, C. W., & Co.	Phiadelphia, Pa.	Imperial dairy feed	8.74	2.81
454	Wallace, L. R.	Middletown	"Mapes" balanced ration for poultry	14.0	4.0
406	Waller, A., & Co.	Henderson, Ky.	Blue grass mixed feed	12.59	3.19
419	Warner Sugar Refining Co.	Chicago, Ill.	Warner's gluten feed	28.0	3.5
477	Weidler, S. W., Co., The	Cincinnati, O.	Weidler's germ food	14.54	6.45

The list of licensed brands may be classified as follows:

Proprietary or mixed feed,	70 brands.	Corn bran,	3 brands.
Meat and bone meal,	16 "	Molasses feed,	3 "
Hominy feed or chop,	13 "	Gluten meal,	2 "
Gluten feed,	12 "	Sugar beet refuse,	2 "
Linseed oil meal,	11 "	Cottonseed feed,	1 "
Distillers' grains,	9 "	Germ oil meal,	1 "
Cottonseed meal,	6 "		
Malt sprouts,	5 "	Total,	154 brands.

ANALYSES OF SAMPLES COLLECTED BY INSPECTOR.

The following table (II) shows the partial analyses of samples of feeding stuffs collected by an inspector in different parts of the State from Jan. 6 to May 6, 1904. In the feeding stuffs law, special emphasis is laid upon two important features—*first*, that the composition of certain feeds shall be correctly guaranteed, as to their contents of protein and fat; *second*, that adulteration of any feed is a violation of the law unless the true composition or adulteration is plainly indicated upon the package containing the same or in which it is offered for sale.

Therefore in the following tabulation the percentage of protein and fat guaranteed are given for comparison with the amount actually present, and in most of the samples the percentage of crude fiber was determined, which served in estimating to what extent some of the materials were adulterated. The table also includes the retail price per ton.

Owing to an excess of moisture in some of the samples collected, which were evidently kept under conditions favorable to the growth of mold, they deteriorated to such an extent that their analysis would represent the goods as being much inferior to what they were when they were sampled in the markets.

Therefore, eight samples of corn and oat products, four of beef scraps, three of meat meal, two of bran and middlings, and one sample each of corn meal, meal and shorts, molasses feed and stock food were not included in the inspection.

TABLE II.

Analysis of Feeding Stuffs

Collected by Inspector.

TABLE II.—ANALYSIS OF FEEDING

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
1179	American Cotton Oil Co., New York,	Fort Edward, E. L. Potter,
1257	Biggs, R. W., & Co., Memphis, Tenn.,	Buffalo, Husted Milling & Elevator Co.,
1095	Bridges, H. E., & Co., Memphis, Tenn.,	New York, W. S. Travis,
1155	Brode, F. W., & Co., Memphis, Tenn.,	Troy, J. D. Westfall & Sons,
1213	Chapin & Co., St. Louis, Mo.,	Watertown, A. H. Herrick & Son.,
1237	Falls, J. G., & Co., Memphis, Tenn.,	Amsterdam, W. N. Carpenter Co.,
1328	Falls, J. G., & Co., Memphis, Tenn.,	Binghamton, G. Q. Moon & Co.,
1220	Hayley & Hoskins, Memphis, Tenn,.	Fulton, Gilbert & Nichols Co.,
1102	Humphreys, Godwin & Co., Memphis, Tenn.	Pleasantville, Washburne Supply Co.,
1307	Humphreys, Godwin & Co., Memphis, Tenn.,	Oneonta, Oneonta Milling Co.,
1232	Hunter Bros. Milling Co., St. Louis, Mo.,	Geneva, J. T. Cook,
1274	Hunter Bros. Milling Co., St. Louis, Mo.,	Jamestown, F. A. Smiley & Co.,
1258	Independent Cotton Oil Co., Memphis, Tenn.,	Buffalo, Buffalo Cereal Co.,
1216	Nat. Cottonseed Products Co., Memphis, Tenn.,	Oswego, H. M. Quigg,
1226	Pettit, Hugh, & Co., Memphis, Tenn.,	Syracuse, H. Frier,
1078	Robinson, G. B., New York,	New York, Clark & Allen,
1204	Sledge & Wells Co., Memphis, Tenn.,	Utica, Ogden & Clark,
1080	American Linseed Co., New York,	Jamaica, J. & T. Adikes,
1312	American Linseed Co., New York,	Oneonta, Morris Bros.,
1114	Chapin & Co., Buffalo,	Dobbs Ferry, Lawrence & Co.,
1275	Chapin & Co., Buffalo,	Jamestown, F. A. Smiley & Co.,
1333	Chapin & Co., Buffalo,	Owego, Truman & Jones,
1341	Chapin & Co., Buffalo,	Spencer, M. D. Fisher & Sons,
1190	Flint Mill Co., Milwaukee, Wis.,	Malone, O. S. Lawrence,
1230	Flint Mill Co., Milwaukee, Wis.,	Rome, G. Oster & Sons,
1279	Flint Mill Co., Milwaukee, Wis.,	Salamanca, H. Neff,
1127	Hauenstein & Co., Buffalo,	Ossining, J. Chadeayne & Sons,
1267	Hauenstein & Co., Buffalo,	Brocton, V. Mathews,
1103	Hunter Bros.,Milling Co., St. Louis, Mo.,	Peasantville, Washburne Supply Co.,
1243	Kellogg, Spencer, Buffalo,	LeRoy, J. Maloney & Son,
1147	Kelloggs & Miller, Amsterdam,	Albany, Barber & Bennett,
1207	Mann Bros. Co., The, Buffalo,	Boonville, A. H. Barber & Son
1271	Mann Bros. Co., The, Buffalo,	Jamestown, D. H. Grandin,
1100	Metzger Seed & Oil Co., Toledo, O.,	White Plains, E. G. Faile,
1270	Metzger Seed & Oil Co., Toledo, O.,	Jamestown, Hayward & Co.,
1128	Union Linseed Co., Troy,	Poughkeepsie, J. J. McCann,
1077	Clements, A. L. & Co., New York,	New York, Clark & Allen,
1228	Midland Linseed Co., Minneapolis, Minn.,	Batavia, C. H. & H. N. Douglass,
1118	Milwaukee Linseed Oil Wks., Mil'kee, Wis.,	Ossining, Crow & Williams,
1143	Biles, The J. W., Co., Cincinnati, O.,	Albany, J. A. Reynolds,
1242	Biles, The J. W., Co., Cincinnati, O.,	Rochester, E. C. Campbell,
1101	Chapin & Co., Buffalo,	Pleasantville, Washburne Supply Co.,
1159	Krause, C. A., Grain Co., Milwaukee, Wis.,	Troy, J. D. Westfall & Sons,
1266	Biles, The J. W., Co., Cincinnati, O.,	Buffalo, Henry & Missert,
1221	Chapin & Co., Buffalo,	Fulton, Gilbert Nichols Co.,
1276	Chapin & Co., Buffalo,	Falconer, Falconer Milling Co.,
1212	American Spirits Mfg. Co., Peoria, Ill.,	Carthage, Jones & Simmons,
1282	American Spirits Mfg. Co., Peoria, Ill.,	Olean, Olean Mills,
1197	Page, J. D., & Co., Syracuse,	Ogdensburg, W. C. Wilcox,
1104	Merchants Distilling Co., Terre Haute, Ind.,	Pleasantville, Washburne Supply Co.,
1294	Merchants Distilling Co., Terre Haute, Ind.,	Buffalo, Chapin & Co.,
1134	Mueller, E. P., Milwaukee, Wis.,	Poughkeepsie, Reynolds Elev. Co.,
1138	Mueller, E. P., Milwaukee, Wis.,	Poughkeepsie, Ambler Bros.,
1262	Heinhold, J. G., Buffalo,	Lancaster, P. Mook,
1265	Kam Malting Co., Buffalo,	Buffalo, Henry & Missert,
1139	Mueller, E. P., Milwaukee, Wis.,	Poughkeepsie, Ambler Bros.,

* Not licensed in this State for

STUFFS COLLECTED BY INSPECTOR.

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	Per ct.	Per ct.	Per ct.		
1179	Cottonseed meal, prime,	42.2	43.0	9.9	9.0		$30.00
1257	*Cottonseed meal, prime,	21.8	41.0–46.0	5.0	7.0–9.0	22.7	25.50
1095	*Cottonseed meal, prime,	43.8	43.0	10.0	9.0–10.0		30.00
1155	Cottonseed meal, Owl,	45.9	43.0	9.5	9.0		29.00
1213	Cottonseed meal, Green diam'd,	45.5	43.0	9.5	9.0		32.00
1237	*Cottonseed meal, South'n beauty,	43.2	43.0	10.2	9.0		30.00
1328	*Cottonseed meal, South'n beauty,	39.8	43.0	11.4	9.0		29 00
1220	*Cottonseed meal, prime,	40.3	43.0	10.0	9.0		27.00
1102	*Cottonseed meal, Dixie,	44.1	43.0	9.0	9.0		30.00
1307	*Cottonseed meal, Dixie,	43.6	43.0	8.0	9.0		28.00
1232	Cottonseed meal, Dixie,	43.1	43.0	8.8	9.0		28.00
1274	Cottonseed meal, prime,	38.7	43.0	6.9	9.0		28.00
1258	*Cottonseed meal, prime,	41.7	43.0	9.7	9.0		26.00
1216	*Cottonseed meal, Indian, prime,	46.2	40.0–45.0	10.8	8.5–10.0		28.00
1226	Cottonseed meal, Horseshoe,	41.2	43.0–47.0	10.2	9.0–11.0		29.00
1078	Cottonseed meal, prime,	39.1	43.0	10.2	9.0		28.00
1204	*Cottonseed meal, Star, prime,	43.5	43.0	8.2	9.0–10.0		28.00
1080	Linseed oil meal, O. P.,	31.3	32.0–36.0	7.4	5.0–7.0		30.00
1312	Linseed oil meal, O. P.,	34.6	32.0–36.0	7.1	5.0–7.0		27.00
1114	*Linseed oil meal, O. P., Export,	30.0	36.0	7.6	7.0		26.00
1275	*Linseed oil meal, O. P., Export,	29.8	36.0	7.4	7.0		28.00
1333	*Linseed oil meal, O. P., Export,	29.9	36.0	8.0	7.0		28.00
1341	*Linseed oil meal, O. P., Export,	28.3	36.0	6.8	7.0		30.00
1190	Linseed oil meal, O. P., Green ov.,	33.0	36.0	8.3	7.0		30.00
1230	Linseed oil meal, O. P., Green ov.,	29.5	32.0–36.0	7.3	5.0–7.0		27.00
1279	Linseed oil meal, O. P., Green ov.,	36.5	32.0–36.0	7.8	5.0–7.0		26.00
1127	Linseed oil meal, O. P.,	36.4	38.32	6.7	7.01		30.00
1267	Linseed oil meal, O. P.,	35.1	35.65	6.6	7.62		29.00
1103	Linseed oli meal, O. P.,	32.3	34.0	7.2	6.5		36.00
1243	Linseed oil meal, O. P.,	32.6	35.94	13.5	5.04		30.00
1147	Linseed oil, meal O. P.,	34.9	36.7	9.2	7.83		28.00
1207	Linseed oil meal, O. P.,	34.7	35.15	8.6	6.05		27.00
1271	Linseed oil meal, O. P.,	34.9	35.15	7.9	6.05		29.00
1100	Linseed oil meal, O. P.,	32.2	32.0–36.0	8.2	5.0–7.0		40.00
1270	Linseed oil meal, O. P.,	32.6	32.0–36.0	7.2	5.0–7.0		25.00
1128	Linseed oil meal, Cow,	32.9	22.09	8.1	6.32		35.00
1077	Linseed cake, ground, O. P.,	28.9	32.0–37.5	7.1	5.5–8.5		25.00
1228	Linseed cake, ground, O. P.,	28.9	32.5–37.5	8.2	5.5–8.5		30.00
1118	*Linseed cake, ground, O. P.,	32.7	34.0–38.0	9.2	5.0–8.0		30.00
	DISTILLERY AND BREWERY BY-PRODUCTS.						
	Distillers' Grains.						
1143	Distillers' dried grains, XXXX,	35.4	33.0	13.5	11.0	12.0	26.00
1242	Distillers' dried grains, XXXX,	33.5	33.0	14.1	11.0		26.00
1101	*Distillers' dried grains, Ajax,	30.9	34.02	14.1	12.03	14.0	25.00
1159	Distillers' dried grains, Blue rib.,	31.6	33.0	12.8	11.0		26.00
1266	Distillers' dried grains, rye (R),	19.1	21.0	7.3	5.0	13.7	20.00
1221	Ajax flakes,	31.1	34.0	13.1	12.0		25.00
1276	Ajax flakes,	32.4	34.0	11.4	12.0		25.00
1212	Gluten feed, Manhattan,	34.8	34.0	11.4	12.0		26.50
1282	Gluten feed, Manhattan,	33.3	34.0	10.2	12.0		28.00
1197	Dairy feed, Empire State,	31.6	36.22	13.4	11.76		28.00
1104	Dairy feed, Merchants',	32.6	34.0	14.3	12.0	12.3	25.00
1294	Dairy feed, Merchants',	31.8	34.0	14.3	12.0		
	Brewers' Grains.						
1134	*Brewers' dried grains,	25.2		6.1		14.2	21.00
1138	Brewers' dried grains,	28.7		7.2		15.0	22.00
	Malt Sprouts.						
1262	Malt sprouts,	24.2		1.7			17.00
1265	Malt sprouts,	25.9	23.81	1.4	1.34		15.50
1139	*Malt sprouts,	25.0		1.5			18.00

1904, prior to May 3 1994.

TABLE II—

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
1357	Nester, S. K., Geneva,	Geneva, S. K. Nester,
1160	Oneonta Milling Co., Oneonta,	Troy, A. Van Valkenburg,
1306	Oneonta Milling Co., Chicago, Ill.,	Oneonta, Oneonta Milling Co.,
1200	Rang, H., & Sons, Chicago, Ill.,	Utica, McLaughlin Bros.,
1130	Pope, Chas., Glucose Co., Chicago, Ill.,	Poughkeepsie, Reynolds Elev. Co.,
1199	Flint Mill Co., Milwaukee, Wis.,	Ogdensburg, V. G. Morey,
1152	Glucose Sugar Refining Co., Chicago, Ill.,	Albany, Knickerbocker Mill & Grain Co.,
1334	Glucose Sugar Refining Co., Chicago, Ill.,	Owego, C. R. Dean,
1142	Illinois Sugar Refining Co., Chicago, Ill.,	Albany, J. A. Reynolds,
1218	National Starch Co., Oswego,	Oswego, National Starch Co.,
1094	New York Glucose Co., New York,	New York, W. S. Travis,
1304	New York Glucose Co., New York,	Oneonta, Oneonta Milling Co.,
1263	Piel Bros. Starch Co., Indianapolis, Ind.,	Lancaster, P. Mook,
1136	Warner Sugar Refining Co., Chicago, Ill.,	Poughkeepsie, Reynolds Elev. Co.,
1327	Warner Sugar Refining Co. Chicago, Ill.,	Binghamton, G. Q. Moon & Co.,
1151	Glucose Sugar Refining Co., Chicago, Ill.,	Albany, Knickerbocker Mill & Grain Co.,
1215	Pratt Cereal Oil Co., Decatur, Ill.,	Oswego, H. M. Quigg,
1256	Pratt Cereal Oil Co., Decatur, Ill.,	Buffalo, Husted Mill & Elev. Co.,
1097	American Hominy Co., Indianapolis, Ind.,	Yonkers, M. A. Austin,
1123	Buffalo Cereal Co., Buffalo,	Peekskill, C. S. Horton & Sons,
1259	Buffalo Cereal Co., Buffalo,	Buffalo, Buffalo Cereal Co.,
1342	Buffalo Cereal Co., Buffalo,	Ithaca, W. J. Davis,
1126	Chapin & Co., Buffalo,	Ossining, J. Chadeayne & Sons,
1281	Chapin & Co., Buffalo,	Olean, Empire Mills,
1309	Hunter Bros. Milling Co., St. Louis, Mo.,	Oneonta, Oneonta, Milling Co.,
1356	Patent Cereals Co., Geneva,	Geneva, Patent Cereals Co.,
1082	Payne, W. H., & Son, New York,	New York, W. H. Payne & Son,
1109	Suffern, Hunt & Co., Decatur, Ill.,	White Plains, Cowen & Co.,
1319	Suffern, Hunt & Co., Decatur, Ill.,	Oneonta, Ford & Rowe,
1137	Toledo Elevator Co., The, Toledo, O.,	Poughkeepsie, Ambler Bros.,
1314	Toledo Elevator Co., The, Toledo, O.,	Oneonta, Morris Bros.,
1290	U. S. Frumentum Co., Detroit, Mich.,	Springville, Victor Mills,
1264	Acme Milling Co., Indianapolis, Ind.,	Lancaster, P. Mook,
1269	Bernet, Craft & Kauffman Mill Co., St. Louis, Mo.,	Fredonia, O. M. & J. R. Hall,
1311	Blish Milling Co., Seymour, Ind.,	Oneonta, Morris Bros.,
1211	Brooks Elevator Co., Minneapolis, Minn.,	Lowville, Louis Bush,
1231	Chapin & Co., Buffalo,	Canastota, F. T. Benjamin,
1268	Commercial Milling Co., Detroit, Mich.,	Brocton, C. P. Lawson,
1353	Empire State Mills, Syracuse,	Tully, W. A. Dewey,
1320	Fertig, H. G., & Co., Minneapolis, Minn.,	Sidney, A. J. Ives,
1210	Flint Mill Co., Milwaukee, Wis.,	Lowville, Louis Bush,
1293	Flint Mill Co., Milwaukee, Wis.,	Buffalo, Flint Mill Co.,
1131	Gardner Mill, The, Hastings, Minn.,	Poughkeepsie, Reynolds Elev. Co.,
1325	Hunter Bros. Milling Co., St. Louis, Mo.,	Norwich, R. D. Eaton Grain & Feed Co.,
1229	Imperial Milling Co., Duluth, Minn.,	Rome, G. Oster & Son.,
1313	Imperial Milling Co., Duluth, Minn.,	Oneonta, Morris Bros.,
1202	Kehlor Bros., St. Louis, Mo.,	Utica, McLaughlin Bros.,
1187	Lawrenceburg Roller Mills Co., Lawrenceburg, Ind.,	Whitehall, The Witherbee Cash Store,
1222	Meyer, J. F., & Son, Springfield, Mo.,	Phoenix, A. C. Parker,
1316	Moore, R. P., Milling Co., Princeton, Ind.,	Oneonta, Morris Bros.,
1315	Morris Bros., Oneonta,	Oneonta, Morris Bros.,
1196	Odgensburg Roller Mills, Ogdensburg,	Ogdensburg, Ogdensburg Roller Mills,
1195	Rex Milling Co., Kansas City, Mo.,	Malone, Ladd & Smallman,
1209	Russell, Henry, Albany,	Boonville, A. H. Barber & Son,

* Not licensed in this State for

(Continued).

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	Per ct.	Per ct.	Per ct.		
1357	Malt sprouts,	31.2	25.0	2.7	2.0		$15.00
1160	*Malt sprouts,	24.3		1.7			18.00
1306	*Malt sprouts,	24.4		1.5			20.00
1200	*Malt sprouts,	26.4		1.5			18.00
	CORN BY-PRODUCTS.						
	Gluten meal.						
1130	Gluten meal, Cream,	38.8	34.12	2.0	3.2		32.00
	Gluten feed.						
1199	Gluten feed, Flint,	22.7	28.5	3.2	3.0		26.00
1152	Gluten feed, Buffalo,	23.4	28.0	3.6	3.0		26.00
1334	Gluten feed, Buffalo,	24.2	28.0	2.9	3.0		24.50
1142	Gluten feed, Pekin,	26.6	28.0	3.5	3.0		26.00
1218	Gluten feed, Queen,	24.3	27.5	2.4	2.5		24.00
1094	Gluten feed, Globe,	25.3	27.0	2.5	3.38		27.00
1304	Gluten feed, Globe,	25.9	27.0	3.7	3.38		26.50
1263	Gluten feed, Piel Bros.,	27.0	27.6	1.9	2.6		24.00
1136	Gluten feed, Warner's,	23.8	28.0	2.5	3.5		27.00
1327	Gluten feed, Warner's,	24.5		3.5			25.50
	Germ oil meal.						
1151	Germ oil meal,	23.2	25.0	9.9	10.5		26.00
	Germaline.						
1215	Germaline,	13.2	12.9	1.1	1.29	4.4	23.00
1256	Germaline,	11.3	12.9	1.4	1.29	4.9	25.00
	Hominy feed.						
1097	Hominy feed,	10.9	10.24	9.4	7.72	4.2	25.00
1123	Hominy meal, Howard,	9.6	10.5	7.9	8.5	3.8	25.00
1259	Hominy feed,	9.7	10.5	5.4	8.5	3.9	20.00
1342	Hominy feed,	9.7	10.5	8.6	8.5	5.3	24.00
1126	Hominy feed, Green diamond,	10.4	11.0	8.2	8.0-9.0	5.1	24.00
1281	Hominy feed, Green diamond,	9.2	11.0	6.6	8.0-9.0	7.1	23.00
1309	Hominy feed,	9.4	11.02	8.4	7.7	5.8	23.50
1356	Hominy feed,	10.1	11.0	8.4	8.0	4.4	21.00
1082	Hominy chop,	10.1	11.49	7.3	8.0	3.6	24.00
1109	Hominy chop,	9.5	11.02	6.7	7.7	5.2	28.00
1319	Hominy feed,	9.2	11.02	7.4	7.7	4.5	23.00
1137	Hominy feed,	9.3	12.6	6.4	8.57	7.7	24.00
1314	Hominy feed,	9.6	12.6	5.1	8.57	6.4	23.00
1290	Hominy feed, Frumentum,	10.1	10.31	7.2	7.98	3.3	22.00
	WHEAT BY-PRODUCTS.						
	Bran and Middlings.						
1264	Acme feed,	15.8		4.7		8.5	24.00
1269	Mixed feed,	16.3		4.5		8.4	23.50
1311	Mixed feed,	15.4		4.6		8.2	25.00
1211	Mixed feed, Royal,	16.3		4.8		8.7	23.50
1231	Mixed feed, Erie,	15.6		4.5		8.2	24.00
1268	Mixed feed, winter wheat,	15.3		4.0		8.2	24.00
1353	Mixed feed,	15.4		4.9		7.7	25.00
1320	Mixed feed. Monogram,	17.3		5.2		7.6	25.00
1210	Mixed feed, Vermont,	17.3		5.1		7.8	24.50
1293	Mixed feed, Vermont,	16.9		5.1		7.8	
1131	Mixed feed, Croesus,	16.3		4.5		10.2	25.00
1325	Mixed feed, Sunshine,	17.6		4.7		7.8	25.00
1229	Mixed feed, Boston,	16.8		5.0		8.9	24.00
1313	Mixed feed, Boston,	16.8		5.2		8.9	24.00
1202	Mixed feed,	15.6		4.5		8.6	23.00
1187	Mixed feed, Snowflake.	15.1		4.6		7.4	27.00
1222	Mixed feed, Model,	16.3		4.5		8.5	23.00
1316	Mixed feed, King,	18.3		4.6		8.6	25.00
1315	Mixed feed, Delaware,	15.1		4.5		7.9	25.00
1196	Mixed feed,	15.0		4.3		5.9	24.00
1195	Mixed feed,	16.5		4.9		8.0	25.00
1209	Mixed feed,	17.3		5.2		7.1	24.50

1904, prior to May 3, 1904.

TABLE II—

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
1310	Russell-Miller Mill Co., Minneapolis, Minn.,	Oneonta, Oneonta Milling Co.,
1321	Sheffield Milling Co., The, Faribault, Minn.,	Sidney, Sidney Flour & Feed Co.,
1194	Sparks Milling Co., Alton, Ill.,	Malone, G. D. Northridge,
1203	Sparks Milling Co., Alton, Ill.,	Utica, G. W. Head Co.,
1208	Stott, David, Detroit, Mich.,	Boonville, A. H. Barker & Son,
1236	Stott, David, Detroit, Mich.,	Amsterdam, W. N. Carpenter Co.,
1201	Thornton & Chester Milling Co., Buffalo,	Utica, McLoughlin Bros.,
1189	Waller, A., & Co., Henderson, Ky.,	Malone, O. S. Lawrence,
1326	Washburn-Crosby Co., Minneapolis, Minn.,	Norwich, H. O. Hale,
1223	Webster Mill Co., Webster, S. D.,	Phoenix, A. C. Parker,
1217	American Cereal Co., Chicago, Ill.,	Oswego, H. W. Barnes & Son,
1288	American Cereal Co., Chicago, Ill.,	Ellicottville, Ellicottville Milling Co.
1198	Stock, F. W., & Sons, Hillsdale, Mich.,	Ogdensburg, W. C. Wilcox,
1219	Gage, W. G., & Co., Fulton,	Fulton, W. G. Gage & Co.,
1157	American Cereal Co., Chicago, Ill.,	Troy, J. D. Westfall & Sons,
1181	American Cereal Co., Chicago, Ill.,	Fort Edward, J. G. Kinne,
1177	Great Western Cereal Co., The, Chicago, Ill.,	Fort Edward, E. L. Potter,
1183	Great Western Cereal Co., The, Chicago, Ill.,	Glens Falls, G. Roberts,
1340	Great Western Cereal Co., The, Chicago, Ill.,	Painted Post, Hodgman Milling Co.,
1169	Barwell, J. W., Waukegan, Ill.,	Hoosick Falls, J. J. Deming & Co.,
1305	Barwell, J. W., Waukegan, Ill.,	Oneonta, Oneonta Milling Co.,
1178	Barwell, J. W., Waukegan, Ill.,	Fort Edward, E. L. Potter,
1277	Barwell, J. W., Waukegan, Ill.,	Salamanca, H. Neff,
1354	Biles, J. W., Co., Cincinnati, O.,	Cazenovia, G. H. Atwell & Son,
1149	Knickerbocker Milling & Grain Co., Albany,	Albany, Knickerbocker Milling & Grain Co.,
1185	Glens Falls Co., Glens Falls,	Glens Falls, Glens Falls Co.,
1258	Hotton, Nicholas, Portville,	Portville, N. Hotton,
1176	Lapham & Parks, Glens Falls,	Glens Falls, Lapham & Parks,
1174	Ashton, E. B., Saratoga Springs,	Saratoga Springs, E. B. Ashton,
1148	Barber & Bennett, Albany,	Albany, Barber & Bennett,
1081	Bowne Bros., Flushing,	Flushing, Bowne Bros.,
1088	Bowne, S. W., Brooklyn,	Brooklyn, S. W. Bowne,
1343	Fall Creek Milling Co., Ithaca,	Ithaca, W. J. Davis,
1076	Morgan, Thomas, Long Island City,	Long Island City, Thos. Morgan,
1278	Neff, Henry, Salamanca,	Salamanca, H. Neff,
1083	Payne, W. H., & Son, New York,	New York, W. H. Payne & Son,
1089	Shaw & Truesdell Co., Brooklyn,	Brooklyn, Shaw & Truesdell Co.,
1105	Washburne Supply Co., Pleasantville,	Pleasantville, Washburne Supply Co.
1170	Tierney & Dalton, Mechanicville,	Mechanicville, Tierney & Dalton,
1166	Buffalo Cereal Co., Buffalo,	Hoosick Falls, Brown & Brownell,
1337	Chase-Hibbard Milling Co., Elmira,	Elmira, Chase-Hibbard Milling Co.,
1346	Dayton Milling Co., Towanda,	Ithaca, J. B. Thayer,
1261	Allen, C. E., Niagara Falls,	Niagara Falls, C. E. Allen,
1286	Ellicottville Milling Co., Ellicottville,	Ellicottville, Ellicottville Milling Co.,
1338	Hayt, S. T., Corning,	Corning, S. T. Hayt,
1339	Hodgman Milling Co., Painted Post,	Painted Post, Hodgman Milling Co.,
1121	Husted Milling & Elevator Co., Buffalo,	Peekskill, E. McCord & Son,
1223	Husted Milling & Elevator Co., Buffalo,	Geneva, C. C. Davidson,
1150	Knickerbocker Milling & Grain Co., Albany,	Albany, Knickerbocker Milling & Grain Co.,
1284	Oliver, Geo., Olean,	Olean, Geo. Oliver,
1182	Roberts, Geo., Glens Falls,	Glens Falls, Geo. Roberts,
1289	Victor Mills, Springville,	Springville, Victor Mills,
1153	Albany City Mills, Albany,	Albany, Albany City Mills,
1086	American Cereal Co., Chicago, Ill.,	New York, H. Ingersoll,
1299	American Cereal Co., Chicago, Ill.,	Medina, S. P. Blood & Co.,
1238	Buffalo Cereal Co., Buffalo,	Amsterdam, Hill & Watson,
1317	Buffalo Cereal Co., Buffalo,	Oneonta, Morris Bros.,
1192	Ellsworth & Co., Buffalo,	Malone, G. D. Northridge,
1084	Great Western Cereal Co., Chicago, Ill.,	New York, Demerest & Carr,
1085	Great Western Cereal Co., Chicago, Ill.,	New York, Demerest & Carr,
1171	Great Western Cereal Co., Chicago, Ill.,	Ballston Spa, W. S. Wheeler's Son
1191	Illinois Cereal Co., Lockport, Ill.,	Malone, G. D. Northridge,
1125	Niagara Mill & Elevator Co., Buffalo,	Ossining, J. Chadeayne & Sons,
1227	Niagara Mill & Elevator Co., Buffalo,	Batavia, C. H. & H. N. Douglass,

* Not licensed in this State for

(*Continued*).

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1310	Mixed feed, Occident,	16.5		5.4		7.8	$25.50
1321	Mixed feed, Gold Mine,	18.5		3.8		7.6	25.00
1194	Mixed feed, Tri-Me,	18.3		4.5		8.0	24.00
1203	Mixed feed,	16.3		4.5		8.4	23.00
1208	Mixed feed, Stott's Honest,	14.5		4.7		8.0	24.50
1236	Mixed feed, Stott's winter wheat,	15.9		4.5		7.8	24.00
1201	Mixed feed,	16.5		5.1		9.3	23.00
1189	Mixed feed, Blue Grass,	10.5	12.59	1.9	3.19	18.0	24.00
1326	Mixed feed, Superior,	16.8		4.7		8.9	24.00
1223	Mixed feed,	16.7		5.2		8.1	22.50
1217	Wheat feed, Buckeye,	15.6	17.75	4.3	4.7	7.5	23.00
1288	Wheat feed, Buckeye,	15.0	17.75	4.2	4.7	7.6	24.00
1198	Wheat feed, Monarch ground,	14.6		4.6		7.4	25.00
	OATS AND THEIR BY-PRODUCTS.						
1219	*Oats, ground,	7.9		3.2		20.5	31.50
1157	*Oat feed, X,	7.2	6.3	3.0	2.38	24.0	14.00
1181	Oat feed, Vim,	8.1	6.3	2.7	2.38	23.6	13.00
1177	*Oat feed, Cream,	5.1	6.97	1.5	2.83	25.6	15.00
1183	Oat feed, Royal,	5.7	7.53	2.1	2.85	27.1	17.00
1340	Oat feed, Royal,	5.1	7.6	2.0	2.8	29.7	15.00
	COMPOUNDED FEEDS. *Proprietary and Otherwise.*						
1169	Blatchford's calf meal,	22.7	26.0	4.5	5.0		70.00
1305	Blatchford's calf meal,	22.1	26.0	4.3	5.0		70.00
1178	Blatchford's sugar and flaxseed,	26.1	28.25	10.2	11.25		70.00
1277	Blatchford's sugar and flaxseed,	27.1	28.25	10.9	11.25		60.00
1354	Biles' ready ration,	24.6	24.0	6.9	7.0	9.1	26.00
1149	Champion feed,	9.9	9.92	2.8	4.01	3.7	22.00
1185	*Common feed,	8.5		2.9		7.6	24.00
1285	Common feed,	8.9	8.38	2.5	4.85	12.7	22.00
1176	Common feed,	8.1	7.5	2.1	3.25	8.4	23.00
1174	Corn and light oats, ground,	9.6		3.4		5.8	23.00
1148	Corn and oats, ground,	8.5		1.2		9.9	22.00
1081	Corn and oats, ground,	9.0		4.3		4.4	26.00
1088	Corn and oats, ground,	7.8		3.8		7.5	21.80
1343	Corn and oats, ground,	12.4		4.0		3.4	27.00
1076	Corn and oats, grouud,	8.3		4.0		4.4	22.00
1278	Corn and oats, ground,	10.3		3.7		7.5	25.00
1083	Corn and oats, ground,	9.1	10.05	6.3	6.21	10.1	
1089	Corn and oats, ground,	8.6		3.5		5.7	22.20
1105	Corn and oats, ground,	9.6		2.7		5.9	31.00
1170	Corn, oats, and rye, ground,	10.5		2.2		7.7	30.00
1166	Corn and oat chop,	8.4	7.5	4.3	3.5	13.0	21.50
1337	Corn and oat chop, No. 2,	9.1		3.6		11.3	21.00
1346	Corn and oat chop, No. 2,	6.8		2.4		9.5	26.00
1261	*Chop feed, Niagara,	10.1	10.42	3.0	4.83	10.3	21.00
1286	Chop feed,	7.5	8.2	1.8	4.4	11.6	23.00
1338	Chop feed, corn and oats,	9.4	10.43	3.4	4.0	9.5	26.00
1339	Chop feed, corn and oats,	10.2	9.69	3.4	3.88	6.2	25.00
1121	Chop feed, Monarch,	7.1	8.09	4.0	4.16	13.8	24.00
1233	Chop feed, Monarch,	11.6	8.09	4.5	4.16	12.6	22.00
1150	Chop feed, corn and oats,	9.8		2.5		5.2	20.00
1284	Chop feed,	7.8	8.13	1.8	4.59	11.8	26.00
1182	Chop feed and corn meal,	8.4		3.4		5.5	24.00
1289	Chop, Golden,	8.8	9.17	3.0	5.84	6.1	20.00
1153	Corn and oat feed, Capitol,	6.3	9.04	2.6	3.75	18.4	21.50
1086	Corn and oat feed, Victor,	8.1	9.0	4.1	4.0	11.2	24.00
1299	Corn and oat feed, Victor,	8.9	9.0	4.6	4.0	11.7	23.00
1238	Corn and oat feed, XXX,	9.6	9.5	4.6	4.5	10.4	25.00
1317	Corn and oat feed, XXX,	9.7	9.5	4.5	4.5	14.0	26.00
1192	Corn and oat feed, De-Fi,	9.4	8.3	2.5	3.0	15.8	20.00
1084	Corn and oat feed, Boss,	7.3	8.27	2.4	3.64	15.4	
1085	Corn and oat feed, Excelsior,	9.4	8.21	4.4	4.58	13.0	
1171	Corn and oat feed, Excelsior	9.6	9.0	6.2	4.2	10.3	24.00
1191	*Corn and oat feed, Anchor,	9.1	9.5	2.4	4.0	14.1	22.00
1125	Corn and oat feed, Niagara,	8.3	8.2	3.5	3.37	6.0	25.00
1227	Corn and oat feed, Niagara,	6.2	8.2	2.9	3.37	16.8	20.00

1904, prior to May 3, 1904.

Table II—

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
1300	Niagara Mill & Elevator Co., Buffalo,	Albion, Woods & Sprague,
1186	Oneonta Milling Co., Oneonta,	Sandy Hill, H. S. & J. S. Shippy,
1303	Oneonta Milling Co., Oneonta,	Oneonta, Oneonta Milling Co.,
1336	Peck, T. R., & Son, Horseheads,	Horseheads, T. R. Peck & Son,
1234	Dixon & Warren, Port Bryon,	Auburn, A. W. Holley,
1145	Oneonta Milling Co., Oneonta	Albany, J. A. Reynolds,
1302	Oneonta Milling Co., Oneonta,	Oneonta, Oneonta Milling Co.,
1132	Buffalo Cereal Co., Buffalo,	Poughkeepsie, Reynolds Elev. Co.,
1168	Buffalo Cereal Co., Buffalo,	Hoosick Falls, Brown & Brownell,
1096	American Cereal Co., Chicago, Ill.,	Yonkers, J. J. Wiffler,
1344	American Cereal Co., Chicago, Ill.,	Ithaca, Holman Bros.,
1173	American Milling Co., Peoria, Ill.,	Ballston Spa., W. S. Wheeler's Son.
1322	American Milling Co., Peoria, Ill.	Norwich, Eaton Grain & Feed Co,,
1167	Buffalo Cereal Co., Buffalo,	Hoosick Falls, Brown & Brownell,
1193	Great Western Cereal Co., Chicago, Ill.,	Malone, G. D. Northridge,
1113	H-O Co., The, Buffalo,	Dobbs Ferry, Lawrence & Co.,
1235	Empire Mills, Olean,	Auburn, J. T. Mollard,
1280	Empire Mills, Olean,	Olean, Empire Mills,
1079	Adikes, J. & T., Jamaica,	Jamaica, J. & T. Adikes,
1098	Brett J. H., Mt. Vernon,	Mt. Vernon, J. H. Brett,
1090	Brooklyn Elev. & Mill. Co., Brooklyn,	Brooklyn, Brooklyn Elev. & Mill. Co.,
1154	Close Bros., Schenectady,	Schenectady, Close Bros.,
1091	Fulton Grain & Milling Co., Brooklyn,	Brooklyn, Fulton Grain & Milling Co.,
1115	Lawrence, N., Co., Dobbs Ferry,	Dobbs Ferry, N. Lawrence Co.,
1092	McCord, H. D., & Son, New York,	New York, H. D. McCord & Son,
1158	Paine Bros. Co., Milwaukee, Wis.,	Troy, J. D. Westfall & Sons,
1093	Travis, W. S., New York,	New York, W. S. Travis,
1172	American Milling Co., Peoria, Ill.,	Ballston Spa., W. S. Wheeler's Son,
1323	American Milling Co., Peoria, Ill.,	Norwich, Eaton Grain & Feed Co.,
1107	Buffalo Cereal Co., Buffalo,	White Plains, R. Young & Bros. Co.,
1087	H-O Co., The, Buffalo,	New York, T. P. Huffman & Co.,
1335	H-O Co., The, Buffalo,	Owego, C. R. Dean,
1146	Oneonta Milling Co., Oneonta.	Albany, J. A. Reynolds,
1291	Lackawanna Mill & Elevator Co., Buffalo,	Buffalo, Lackawanna Mill & Elev. Co.,
1119	Bagley, G. A. Peekskill,	Peekskill, G. A. Bagley,
1116	Crow & Williams, Ossining,	Ossining, Crow & Williams,
1308	Oneonta Milling Co., Oneonta,	Oneonta, Oneonta Milling Co.,
1359	Staples, A. S., Rondout,	Rondout, A. S. Staples,
1135	Mueller, E. P., Milwaukee, Wis.,	Poughkeepsie, Reynolds Elev. Co.,
1175	Mueller, E. P., Milwaukee, Wis.,	Saratoga Springs, D. Gibbs & Son,
1324	Mueller, E. P., Milwaukee, Wis.,	Norwich, Eaton Grain & Feed Co.,
1225	Rankin, M. G., Co., Milwaukee, Wis.,	Syracuse, H. Frier,
1140	Toledo Elevator Co., The, Toledo, O.,	Poughkeepsie, Reynolds Elevator Co.,
1332	Toledo Elevator Co., The, Toledo, O.,	Binghamton, Baker Bros.,
1108	American Cereal Co., Chicago, Ill.,	White Plains, R. Young & Bros. Co.,
1345	American Cereal Co., Chicago, Ill.,	Ithaca, J. B. Thayer,
1112	Flint Mill Co., Milwaukee, Wis.,	Dobbs Ferry, Lawrence & Co.,
1292	Flint Mill Co., Milwaukee, Wis.,	Buffalo, Flint Mill Co.,
1124	Strong, Lefferts Co., The, New York,	Peekskill, G. F. Cooley,
1355	Unknown,	Geneva, C. C. Davison,
1156	Diamond Elev. & Mill. Co., Minn.,	Troy, J. D. Westfall & Sons,
1164	American Cereal Co., Chicago, Ill.,	Troy, Young & Halstead,
1106	Buffalo Cereal Co., Buffalo,	White Plains, R. Young & Bros. Co.,
1111	H-O Co., The, Buffalo,	Dobbs Ferry, Lawrence & Co.,
1244	H-O Co., The, Buffalo,	Batavia, E. J. Salway,
1350	Cornell Incubator Mfg. Co., The, Ithaca.	Ithaca, The Cornell Incubator Mfg. Co.,
1252	Cyphers Incubator Co., Buffalo,	Buffalo, Cyphers Incubator Co.,
1331	Harding, Geo. L., Binghamton,	Binghamton, G. L. Harding,
1122	Puritan Poultry Farms & Mfg. Co., N. Y.,	Peekskill, E. McCord & Son,

* Not licensed in this State for

(*Continued*).

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1300	Corn and oat feed, Niagara,	7.0	8.2	3.0	3.37	15.6	$24.00
1186	Corn and oat feed, Arrow,	8.8	9.0	3.5	3.75	4.2	26.00
1303	Corn and oat feed, Arrow,	8.7	9.0	2.5	3.75	3.3	22.50
1336	Corn and oat feed,	7.9		1.1		9.7	23.00
1234	Corn and oat feed provender,	7.7		2.7		13.3	28.00
1145	Corn and oat feed provender, choice,	7.3	8.75	2.3	3.5	11.4	20.50
1302	Corn and oat feed provender, choice,	8.4	8.75	1.6	3.5	18.3	21.50
1132	Creamery feed,	19.8	20.0	5.4	5.0	12.1	28.00
1168	Creamery feed,	17.6	20.0	5.1	5.0	12.2	27.00
1096	Dairy feed, Quaker,	14.7	14.0	4.7	3.5	17.1	28.00
1344	Dairy feed, Quaker,	13.6	14.0	4.3	3.5	18.9	25.00
1173	Dairy feed, Sucrene,	14.4	16.5	4.1	3.5	12.9	25.00
1322	Dairy feed, Sucrene,	15.5	16.5	2.5	3.5	11.4	24.00
1167	Dairy feed,	12.8	14.0	3.6	4.0	14.2	24.00
1193	*Dairy feed. Great Western,	8.1	12.25	2.2	3.2	19.9	17.00
1113	Dairy feed, H-O,	18.1	18.0	4.3	4.5	13.8	26.00
1235	Empire feed,	7.4	7.63	2.3	2.97	7.5	24.00
1280	Empire feed,	7.6	7.63	1.7	2.97	9.6	23.00
1079	Ground feed,	9.2	8.75	2.7	3.0	7.9	20.00
1098	Ground feed,	11.7		4.6		5.6	28.00
1090	Ground feed,	9.3		4.0		5.3	28.00
1154	Ground feed,	9.7		3.0		5.8	22.00
1091	Ground feed,	12.8		3.2		12.5	20.00
1115	Ground feed,	6.8		2.9		15.5	20.00
1092	Ground feed,	7.9		3.5		10.4	
1158	Ground feed, Puritan,	7.3	8.5	2.6	3.25	15.3	20.50
1093	Ground feed,	12.9		3.2		7.4	24.00
1172	Horse feed. Sucrene,	14.8	13.5	2.8	4.5	10.6	27.00
1323	Horse feed, Sucrene,	15.0	13.5	2.3	4.5	10.9	26.00
1107	Horse feed,	12.3	12.0	4.9	4.5	10.5	29.00
1087	Horse feed, H-O,	11.5	12.0	4.1	4.5	9.4	28.00
1335	Horse feed, H-O,	11.1	12.0	4.0	4.5	11.7	28.00
1146	Horse feed, Monarch,	13.8	13.0	4.0	5.75	7.2	28.00
1291	Horse and cattle feed Lackawanna special,	7.4	10.93	2.6	3.43	12.4	21.00
1119	Mixed feed, G. W. Bagley & Son's,	16.0	16.0	5.4	6.0	6.7	26.00
1116	Mixed feed, C. & W.,	10.3	10.0	2.9	4.5	7.5	24.00
1308	Mixed feed, rye,	15.8	14.75	3.2	3.5	5.4	24.00
1359	Mixed feed, Arcade,	7.4	10.42	4.7	5.86	14.3	26.00
1135	Molasses feed for horses,	17.1	21.81	3.4	2.73	11.9	21.00
1175	Molasses feed for horses,	24.0	21.81	4.1	2.73	10.9	20.00
1324	Molasses feed for horses,	22.4	21.81	3.7	2.73	10.0	24.00
1225	Molasses feed for horses,	22.2	21.81	3.0	2.73	9.8	21.00
1140	Star feed,	8.3	11.4	6.2	7.31	10.0	24.00
1332	Star feed,	9.7	11.4	5.8	7.31	8.0	24.00
1108	Stock food, Schumacker's,	11.6	13.0	5.4	5.0	12.4	29.00
1345	Stock food, Schumacker's,	11.8	13.0	4.8	5.0	11.9	27.00
1112	Stock food, Apex,	14.9	16.0	4.8	4.0	16.6	26.00
1292	Stock food, Apex,	14.1	16.0	4.7	4.0	16.4	
1124	*Stock food, Lenox,	7.3	9.88	3.8	3.27	12.2	22.00
1355	*Wheat bran and oat hulls,	8.9		2.5		25.8	16.00
1156	Yellow feed, "O. O.",	11.5	10.51	5.6	5.75	6.6	24.00
	POULTRY FOODS.						
1164	Poultry food, American,	13.3	14.0	6.4	4.5	5.0	35.00
1106	Poultry food, American,	15.2	17.0	5.3	5.0	4.9	35.00
1111	Poultry food, H-O,	16.4	17.0	5.6	5.5	4.9	28.00
1244	Poultry food, H-O,	17.8	17.0	5.9	5.5	6.2	35.00
1350	*Chick food, Stan. Peep O'Day,	10.8	15.0	4.2	7.75		50.00
1252	Chick food,	10.7	10.47	2.2	3.31	4.9	39.00
1331	*Chick food, Unexcelled baby,	11.1	15.0	2.4	7.75		50.00
1122	Chick food, Puritan,	12.4	12.5	6.7	7.0	5.3	60.00

1904, prior to May 3, 1904.

TABLE II—

Collection No.	NAME AND ADDRESS OF MANUFACTURER OR JOBBER.	Sampled at
1254	Cyphers Incubator Co., Buffalo,	Buffalo, Cyphers Incubator Co.,
1161	Cyphers Incubator Co., Buffalo,	Troy, H. W. Gordinier,
1255	Cyphers Incubator Co., Buffalo,	Buffalo, Cyphers Incubator Co.,
1253	Cyphers Incubator Co., Buffalo,	Buffalo, Cyphers Incubator Co.,
1110	H-O Co., The, Buffalo,	White Plains, Corven & Co.,
1133	Harding, Geo. L., Binghamton,	Poughkeepsie,, Reynolds Elevator Co.,
1296	Armour & Co., Chicago, Ill.,	Lockport, J. T. Darrison,
1248	Armour & Co., Chicago, Ill.,	Buffalo, Harvey Seed Co.,
1117	Berg Co., The, Philadelphia, Pa ,	Ossining, Crow & Williams,
1287	Barwell, J. W., Waukegan, Ill.,	Ellicottville, Ellicottville Milling Co.,
1348	Cornell Incubator Mfg. Co., The, Ithaca,	Ithaca, The Cornell Incubator Mfg. Co.,
1144	Harding, Geo. L., Binghamton,	Albany, J. A. Reynolds,
1329	Harding, Geo. L., Binghamton	Binghamton, Geo. L. Harding,
1129	Bowker Fertilizer Co., New York,	Poughkeepsie, J. J. McCann,
1301	Bowker Fertilizer Co., New York,	Albion, Woods & Sprague,
1246	Romaine, DeWitt, New York,	Buffalo, Harvey Seed Co.,
1295	Armour & Co., Chicago, Ill.,	Lockport, J. T. Darrison,
1349	Cornell Incubator Mfg. Co., The. Ithaca,	Ithaca, The Cornell Incubator Mfg. Co.,
1141	Darling & Co., Chicago, Ill.,	Hudson, J. H. Vosburgh,
1239	Darling & Co., Chicago, Ill.,	Gloversville, M. D. Kasson,
1206	Finn, G. M., Syracuse,	Utica, M. T. Jones,
1163	Stanton, H. M., Schenectady,	Troy, Young & Halstead,
1247	Wuychet Fertilizer Co., Dayton, O.,	Buffalo, Harvey Seed Co.,
1298	Armour & Co., Chicago, Ill.,	Lockport, J. T. Darrison,
1251	Cudahy Packing Co. The, Kan. C., Kan.,	Buffalo, Cyphers Incubator Co.,
1249	Swift & Co., Chicago, Ill.,	Buffalo, Harvey Seed Co.,
1120	Pioneer Cereal Co., Akron, O.,	Peekskill, G. A. Bagley,
1352	Ryan Bros., Jamesville,	Jamesville, Ryan Bros.,
1351	Smith, A. V., Marcellus Falls,	Marcellus Falls, A. V. Smith,
1214	Alma Sugar Co., Alma, Mich.,	Watertown, A. H. Herrick & Son,

*Not licensed in this State for 1904, prior to

(*Concluded*).

Collection No.	Name of feed.	Protein. Found.	Protein. Guaranteed.	Fat. Found.	Fat. Guaranteed.	Crude fiber found.	Price per ton.
		Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
1254	Forcing food,	16.2	18.17	4.0	7.11	5.5	$39.00
1161	Laying food,	15.5	15.26	4.2	5.5	5.2	40.00
1255	Laying food,	15.7	15.26	1.8	5.5	5.3	
1253	Scratching food,	11.1	11.34	2.9	3.17	5.7	
1110	Scratching food, H-O,	10.6	12.0	3.1	3.0	2.8	40.00
1133	Egg builder ration, Harding's,	13.1		3.9			45.00
1296	Poultry bone, coarse,	22.9	24.0–26.0	1.0	5.0–6.0		45.00
1248	Poultry bone, fine,	25.7	25.0	0.9			40.00
1117	Poultry meat,	58.1		16.8			55.00
1287	†Poultry meats, Blatchford's	29.9	33.0	7.1	10.0		60.00
1348	*Meat meal, Cornell	36.6	55.0–65.0	17.1	10.0–15.0		45.00
1144	Meat meal, celebrated	34.1	55.0–65.0	13.6	10.0–15.0		50.00
1329	Meat meal, celebrated	35.6	55.0–65.0	14.1	10.0–15.0		45.00
1129	Animal meal,	34.1	30.0	10.0	5.0		43.00
1301	Animal meal,	40.4	30.0	9.0	5.0		50.00
1246	Boiled beef and bone,	45.6	45.0	17.6	15.0		40.00
1295	Meat and bone,	51.4	45.0	12.4	8.0		50.00
1349	*Beef scraps, Cornell standard,	34.1	42.0–50.0	22.1	30.0–35.0		50.00
1141	Beef scraps, pure, ground,	56.5	55.0–65.0	13.2	10.0–15.0		50.00
1239	Beef scraps, pure, ground,	52.0	55.0–65.0	11.9	10.0–15.0		60.00
1206	Beef scraps, ground,	41.6	42.64	19.1	19.12		50.00
1163	Beef scraps,	40.6	50.0	25.6	9.0		40.00
1247	*Beef scraps, ground,	58.8	50.0	12.6	9.0		40.00
1298	Blood meal,	83.4	87.0	0.2	0.2		70.00
1251	*Blood meal,	82.8		0.3			70.00
1249	*Blood meal,	83.8	87.0	0.5			40.00
	Unclassified Feeds.						
1120	Barley feed, Pioneer,	13.7	15.0	3.0	4.61	8.2	25.00
1352	Barley meal	13.9		3.4		9.2	21.00
1351	Barley meal,	13.1	14.8	4.1	3.4	10.7	21.00
1214	Beet pulp, dried,	8.4		0.7		19.2	18.00

May 3, 1904. † A condimental preparation.

The samples analyzed may be classified as follows:

TABLE III.—CLASSIFICATION OF SAMPLES ANALYUED.

NAME OF FEED.	No. samples.	No. brands.
Cottonseed meal	17	13
Linseed oil meal	19	10
Linseed cake, ground	3	3
Distillers' grains	12	8
Brewers' grains	2	1
Malt sprouts	7	6
Gluten meal	1	1
Gluten feed	10	7
Germ oil meal	1	1
Germaline	2	1
Hominy feed or chop	14	10
Mixed feeds (bran and middlings)	35	30
Oats and their by-products	6	5
Compounded feeds, proprietary and otherwise	96	74
Poultry foods	34	29
Miscellaneous feeds	4	4
Total	263	203

BRANDS ESPECIALLY MENTIONED.

The brands mentioned in Table IV are named for special consideration either because they are not what their name would indicate or because they are compounded by the use in part of inferior materials, oat hulls being the undesirable ingredient in nearly all cases.

It is unquestionably true that oat hulls have slight value as food for cattle, and their introduction into a compounded feed lowers the quality of the feed and should proportionately lower its price.

TABLE IV.—BRANDS NAMED FOR SPECIAL CONSIDERATION.

Collection No.	NAME OF FEED.	Protein.	Fat.	Fiber.
		Per ct.	*Per ct.*	*Per ct.*
1257	Cottonseed meal,	21.8	5.0	22.7
1189	Mixed feed. Blue Grass,	10.5	1.9	18.0
1219	Oats, ground,	7.9	3.2	20.5
1157	Oat feed, X,	7.2	3.0	24.0
1181	Oat feed, Vim,	8.1	2.7	23.6
1177	Oat feed, Cream,	5.1	1.5	25.6
1183	Oat feed, Royal,	5.7	2.1	27.1
1340	Oat feed, Royal,	5.1	2.0	29.7
1153	Corn and oat feed, Capitol,	6.3	2.6	18.4
1086	Corn and oat feed, Victor,	8.1	4.1	11.2
1299	Corn and oat feed, Victor,	8.9	4.6	11.7
1238	Corn and oat feed, XXX	9.6	4.6	10.4
1317	Corn and oat feed, XXX,	9.7	4.5	14.0
1192	Corn and oat feed, De-Fi,	9.4	2.5	15.8
1084	Corn and oat feed, Boss,	7.3	2.4	15.4
1085	Corn and oat feed, Excelsior,	9.4	4.4	13.0
1171	Corn and oat feed, Excelsior,	9.6	6.2	10.3
1191	Corn and oat feed, Anchor,	9.1	2.4	14.1
1227	Corn and oat feed, Niagara,	6.2	2.9	16.8
1300	Corn and oat feed, Niagara,	7.0	3.0	15.6
1234	Provender,	7.7	2.7	13.3
1145	Provender, choice corn and oat,	7.3	2.3	11.4
1302	Provender, choice corn and oat,	8.4	1.6	18.3
1115	Ground feed,	6.8	2.9	15.5
1158	Ground feed, Puritan,	7.3	2.6	15.3
1359	Mixed feed, Arcade,	7.4	4.7	14.3
1335	Wheat bran and oat hulls,	8.9	2.5	25.8
1193	Dairy feed, Great Western,	8.1	2.2	19.9

COMMENTS ON THE RESULTS OF INSPECTION.

A study of the figures showing the results of the inspection up to May 3 reveals the fact that the samples representing quite a large number of brands contained considerably less protein than called for by the guarantees. In all, at least 52 samples showed a larger deficit than would be regarded as reasonable.

The deficit occurred as follows:

Cottonseed meal	5 samples.
Linseed meal	9 "
Distillers' dried grains	4 "
Gluten feed	4 "
Hominy feed	6 "
Compounded and proprietary feeds	18 "
Poultry foods	6 "
	52

One brand, licensed as cottonseed meal, sold by the Husted Milling and Elevator Co., of Buffalo, N. Y., and recorded as manufactured by R. W. Biggs & Co., of Memphis, Tenn., was found to contain only 21.8 per ct. of protein, whereas the minimum guarantee is 41 per ct.

The material is evidently cottonseed feed, or cottonseed meal mixed with ground hulls. Such a feed is fraudulent in its character.

APPENDIX.

I. Periodicals Received by the Station.

II. Meteorological Records.

Appendix.

PERIODICALS RECEIVED BY THE STATION.

Acclimitation	Complimentary.
Acker und Gartenbau Zeitung	"
Agricultural Epitomist	"
Agricultural Gazette of New South Wales	"
Agricultural Journal and Mining Record (Natal)	"
Agricultural Journal of the Cape of Good Hope	"
Agricultural Ledger	"
Agricultural News	"
Allegan Gazette	"
American Agriculturist	Subscription.
American Chemical Journal	"
American Chemical Society Journal	"
American Cultivator	Complimentary.
American Entomological Society, Transactions	Subscription.
American Fancier	"
American Fertilizer	"
American Florist	"
American Gardening	"
American Grange Bulletin	Complimentary.
American Grocer	"
American Hay, Flour and Feed Journal	"
American Journal of Physiology	Subscription.
American Naturalist	"
American Philosophical Society, Proceedings	Complimentary.
American Poultry Journal	"
American Stock Keeper	"
Analyst	Subscription.
Annales de l'Institut Pasteur	"
Annals and Magazine and Natural History	"
Annals of Botany	"
Archiv der gesammte Physiologie (Pflueger)	"
Archiv fuer Hygiene	"

Association Belge des Chimistes, Bulletin.....	Complimentary.
Australian Garden and Field................	"
Baltimore Weekly Sun......................	"
Beet Sugar Gazette........................	"
Beiträge zur Chemischen Physiologie und Pathologie	Subscription.
Berichte der deutschen botanischen Gesellschaft.	"
Berichte der deutschen chemischen Gesellschaft.	"
Bibliographia Agronomica Universalis........	"
Biochemisches Centralblatt	"
Biological Bulletin	"
Biologisches Centralblatt	"
Boletim da Agricultura.....................	Complimentary.
Boston Society of Natural History, Proceedings,	Subscription.
Botanical Gazette	"
Botanische Zeitung	"
Botanisches Centralblatt	"
Botaniste, Le	"
Breeders' Gazette	"
Buffalo Society of Natural Sciences, Bulletin..	Complimentary.
Bulletin of the Department of Agriculture, Jamaica	"
Caledonia Era	"
California Fruit Grower....................	Subscription.
Canadian Entomologist	"
Canadian Horticulturist	Complimentary.
Centralblatt fuer Agrikultur-Chemie...........	Subscription.
Centralblatt fuer Bakteriologie und Parasitenkunde	"
Chemical News	"
Chemical Society, Journal..................	"
Chemiker Zeitung	"
Chemisches Centralblatt	"
Chicago Daily Drovers' Journal.............	Complimentary.
Chicago Dairy Produce.....................	"
Cincinnati Society of Natural History, Journal,	"
Columbus Horticultural Society, Journal.....	"
Commercial Poultry	"
Country Gentleman	Subscription.

Country World	Complimentary.
Dairy and Creamery..........................	"
Detroit Free Press..........................	"
Elgin Dairy Report..........................	"
Elisha Mitchell Scientific Society, Journal....	"
English Catalogue of Books..................	"
Entomological News	Subscription.
Entomological Society of Washington, Proceedings	"
Entomologische Zeitschrift	"
Entomologist	"
Entomologists' Record	"
Fanciers' Review	Complimentary.
Farm and Fireside..........................	"
Farm Journal	"
Farm Life	"
Farm News	"
Farm Poultry Semi-Monthly..................	"
Farm, Stock and Home.......................	"
Farmers' Advocate	"
Farmers' Call	"
Farmers' Guide	"
Farmers' Progress	"
Farm and Live Stock Journal................	"
Farmers' Sentinel	"
Farmers' Tribune	"
Farmers' Visitor	"
Farmers' Voice	"
Feather	Subscription.
Feathered World	"
Floral Life	"
Florists' Exchange	"
Flour and Feed.............................	Complimentary.
Fruit Grower	"
Fuehling's Landwirtschaftliche Zeitung......	Subscription.
Garden	"
Gardeners' Chronicle	"
Gardening	"
Gartenwelt	"

Gleanings in Bee Culture	Complimentary.
Green's Fruit Grower	"
Hartwick Seminary Monthly	"
Hedwigia	Subscription.
Herd Register	Complimentary.
Hoard's Dairyman	"
Holstein-Friesian Register	"
Holstein-Friesian World	"
Homestead	"
Horticultural Visitor	"
Hygienische Rundschau	Subscription.
Indiana Farmer	Complimentary.
Insect World	"
Ithaca Democrat	"
Jahresbericht der Agrikultur-Chemie	Subscription.
Jahresbericht Garungs-Organismen	"
Jahresbericht der Nahrungs und Genussmittel	"
Jahresbericht Pflanzenschutzes	"
Jahresbericht der Tier-Chemie	"
Jersey Bulletin	Complimentary.
Journal of Agriculture, Victoria	"
Journal de Botanique	Subscription.
Journal of the Department of Agriculture of Western Australia	Complimentary.
Journal of Experimental Medicine	Subscription.
Journal fuer Landwirtschaft	"
Journal of Mycology	"
Journal of Physiology	"
Just's Botanischer Jahresbericht	"
Kimball's Dairy Farmer	Complimentary.
Landwirtschaftlicher Jahrbuch	Subscription.
Landwirtschaftlicher Jahrbuch der Schweiz	"
Landwirtschaftlicher Versuchs-Stationen	"
Live Stock and Dairy Journal	Complimentary.
Metropolitan and Rural Home	"
Milch Zeitung	Subscription.
Mirror and Farmer	Complimentary.
Missouri Agricultural College Farmer	"
Monthly Weather Review	"

National Nurseryman	Complimentary.
National Farmer and Stock Grower	"
National Stockman and Farmer	"
Naturaliste Canadienne	"
Nebraska Farmer	"
New England Farmer	"
New York Academy of Science, Annals and Transactions	Subscription.
New York Botanical Garden, Bulletin	Complimentary.
New York Entomological Society, Journal	Subscription.
New York Farmer	Complimentary.
New York Tribune Farmer	"
North American Horticulturist	"
Northwest Pacific Farmer	"
Oesterreichische Chemiker Zeitung	Subscription.
Ohio Poultry Journal	"
Pacific Coast Fanciers' Monthly	"
Pacific Fruit World	Complimentary.
Pacific Rural Press	Subscription.
Photo-Miniature	"
Photographic Times-Bulletin	"
Popular Agriculturist	Complimentary.
Poultry Herald	Subscription.
Poultry Keeper	Complimentary.
Poultry Industry	"
Poultry Monthly	"
Practical Poultryman and Poultry Star	"
Practical Farmer	"
Practical Fruit-Grower	"
Praktische Blätter fuer Pflanzenschutz	Subscription.
Queensland Agricultural Journal	Complimentary.
Reliable Poultry Journal	Subscription.
Republic	"
Revue Generale de Botanique	"
Revue Horticole	"
Revue Mycologique	"
Royal Agricultural Society, Journal	"
Royal Horticultural Society, Journal	Complimentary.
Rural New Yorker	Subscription.

Salt Lake Herald	Complimentary.
Saint Louis Academy of Science, Transactions	"
Sanitary Inspector	"
Science	Subscription.
Scientific Roll, Bacteria	"
Society of Chemical Industry, Journal	"
Societe Entomologique de France, Bulletin	Complimentary.
Societe Mycologique de France, Bulletin	Subscription.
Southern Planter	Complimentary.
Southern Tobacconist	"
Southern Farm Magazine	"
Southwestern Farmer and American Horticulturist	"
Station, Farm and Dairy	"
Stazione Sperimentale Agrarie Italiane	"
Successful Farming	"
Sugar Beet	"
Texas Stockman and Farmer	"
Torrey Botanical Club, Bulletins and Memoirs	Subscription.
Transvaal Agricultural Journal	Complimentary.
Up-to-Date Farming and Gardening	"
Utica Semi-Weekly Press	"
Wallace's Farmer	"
West Indian Bulletin	"
West Virginia Farm Review	"
Western Fruit-Grower	"
Western Plowman	"
Woman's Home Companion	"
Zeitschrift fuer Analytische Chemie	Subscription.
Zeitschrift fuer Biologie	"
Zeitschrift fuer Entomologie	Complimentary.
Zeitschrift fuer Fleisch und Milch Hygiene	Subscription.
Zeitschrift fuer Pflanzenkrankheiten	"
Zeitschrift fuer Physiologische Chemie	"
Zeitschrift fuer Untersuchung der Nahrungs und Genussmittel	"
Zoological Record	"
Zoologischer Anzeiger	"

METEOROLOGICAL RECORDS FOR 1904.

Reading of Maximum and Minimum Thermometers for 1904.

DATE.	January.		February.		March.		April.		May.		June.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.
1	29	15	35	7	34	29	61	36	61.0	40.5	73	51
2	18	—1	22	—1	42	23	56	34	68	37	74	55
3	11	—4	18	9	43	18	38	21	74	40	75	58.5
4	13	—6	16	1	19	8	46.5	24.5	78	46	80	59
5	10	—10	18	9	29	10	57	29.5	78	46	89	63
6	28	0	46	14	40	24	57	29.5	80	48	88	69
7	30	22	58	40	45	36	54	40	78	51	77	62
8	34	21	47	5	43	35	59	31	76.5	53	70	56
9	33	20	11	—1	36	18	66	45	75	52	65	55
10	24	18	12	—2	23.5	17	51	37	65.5	41	70	50
11	23	16	16	3	23	17	49	36	65	40	75	46
12	26	15	15	4	26	15	47	36	72	31.5	80	45
13	35	23	21	12	26	17	36.5	26	84	53	79	46
14	32	23	26	10	29	16	37	16	78	53	78	53
15	21	17	30	7	33.5	24	35	19	57	46	80	59
16	34	11	7	—18	29	20.5	34.5	23	56	42	79	59
17	32	11	6	—9	33	9	48	22.5	64	39	76	45
18	11	0	14	2	36	28	52	29	65	49	79	55.5
19	14	—14	18	9	39.5	32	48	25	67	54	83	56
20	32	10	27	7	46	28	31.5	19	65	45.5	86.5	58
21	33	23	42	9	36	18	45	27	75	47	86	6
22	45	22	43	25	50	32	52	25	82	51	73	55
23	48	31	38	21	51	32	62	32	76	61	77	49
24	32	15	37	19	55	26	67.5	42	75	57	89	56
25	16	1	20	—5	57	41	61	43	88	53	89	68
26	28	5	21	3	58	31	48	43	83	64.5	88	69
27	30	9	33	7	33	24	50	40	80	51	79	54
28	21	—1	35	24	30	12	52	43	72	45	72	49
29	25.5	6	37.5	26	42	17	59	45	77	46	83	59
30	31	12	......	......	52	31	57	46	76	58	83	62
31	40	23	......	......	48	36	......	......	63	45	......	......
Averages	27.1	10.7	38	8.2	38.3	23.4	50.6	32.2	72.7	47.9	79.2	56.3

READING OF MAXIMUM AND MINIMUM THERMOMETERS FOR 1904—(*Concluded*).

DATE.	July.		August.		September.		October.		November.		December.	
	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min.	5 P. M. Max.	5 P. M. Min
1	75	57	89	69	74	50	60	49	51	31	31	22
2	70	53.5	85	61	87.5	63	58	47	57.5	29	28	18
3	69	49	80	57	88	67	54	40	65	41	19.5	15
4	86.5	52	82.5	56	70	56	59	39	51	39	26	16
5	84	59	86	63	68	51	71	43	44	33	29	19
6	78	51	82	58	69	41	62	39	36	26	26	21
7	75 5	57	80	55	78	43	50.5	29	39	30	34	24
8	84	57	77	58	75	51.5	55	39	42	27	31.5	19
9	83	64	76.5	47	63	51	57	51	40	26	19	10.5
10	81	63	75	60	78	55	81	52	41	25	10.5	4
11	85	60.5	71	62	78	58	76	49	39	28	17	9
12	81	63	77	56	75	58	50	41	54	27	24	16
13	73	52	80	56.5	72	46	45.5	38	42	29	24	13
14	83	53	77	58	73	61	54.5	31	39	32	18	12
15	89	63	84	55	64	48	53	32	54	28	18	12
16	86	63	83	62	71	43	37	29	46.5	36	21	—2
17	86	57	82	62	77	54	68	34	37	16	22	7
18	90	72	73	57	85	58	70	45	47	23	23	19
19	93	66	74	45	77	56	74	44	57.5	28	37	19
20	89	61	78.5	60	70	50	67	51.5	62	41	31.5	22
21	80	55	82	57	61	41	66	45	58	34	30	11
22	77	55	88	63	57	34	52	43	53	28	32	8
23	76.5	60	75	54	66.5	33	48	35	51	29	53	30
24	79	63	79.5	49	72	54	52	32	46	35	52	9
25	77	60	89.5	58	71	61.5	52.5	42	45	25	21.5	—1
26	80	62	85	51	70	53	49	37	36.5	25	30	21
27	83	57	79.5	48	69	51	40	30	30	20	43	29
28	76	63	81	52	68	40	52	27.5	22	14	47	20
29	74	57	80	59	79.5	50	61	35	42	9	24	17
30	83	52	75	49	72	59	55	33	42	29	37	20
31	89	69	72	47	....	....	49	22	....	....	51	25
Averages	81.1	58.9	80	56.3	72.6	51.2	58	38.9	45.7	28.1	29.4	15.6

READINGS OF THE STANDARD AIR THERMOMETER.

1904.	January.			February.			March.			April.			May.			June.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	22	27.5	17	19	19	7	30	31.5	32	40	44	56	48	56	59	56	67	68
2	1	1	1	0	10	21.5	30	40	39	45	43	37.5	49	65	66	60	67	72
3	—3	5	11	11	13	15.5	39	41	18	22	25.5	31	55	71	73	64	71	72
4	—3	3	—4	2	10	11	9	15.5	16	28	42	45	57	75	76	61	73.5	77
5	—4	6	4	13	16	15	14	23.5	28	39	52	55.5	55	74	77	72	84	87
6	19	26	25	44	43	43	29	39	38	33	50	53.5	56	77.5	79	74	80.5	77
7	24	28	23	45	48	47	38	41	43	43	51	51	62	78	73	67	74	70
8	27	31	32	6	9	5	36	38.5	36	35	57	52	61	73	68	58	60	59
9	25	26	21	5	9	8.5	19	23	23.5	52	63	51	58	71	57	58	64	61
10	18	23	21	4	8.5	10	18	19	18	39	45	49	53	62	64	53	64	69
11	18.5	23	21	9	12	13	19	19	23	38	39	39	44	51	47	58	73	72
12	18	22	24	7	13	10	16	21	25	40	45	36.5	44	60	70.5	63	75	77
13	31	34	32	10	20	12	19	24	25	27.5	34.5	29	57	80	78	60	73.5	75
14	26.5	27.5	24	22	26	26	21	27	27.5	24	35	32	58	76	54	62	72	73
15	18	21	20	12	15	7	25	33	28.5	31	33	30	47	51	48	65	76	78
16	21	25	31	—7	0	0	21.5	23	22	25	34	29	44	54	53.5	60	69	68
17	16	13	11	0	6	6	11	29	31	28	40	47	44	60	60	59	71	76
18	2	3.5	0	5	13	10	31	36	33	35	51	48	53	65	63	68	77	75
19	—10	6	13	11	15	15	33	39	39	34	28.5	26	60	65	58	70	79	79
20	21	28	32	8	22	26	29	30	31	22	28	30.5	52	63	60	69	81.5	75
21	26	27	24	21	40	38	22	31.5	36	32	39	45	54	70	74	71	82	69
22	36	40	44	37	29	26	36	45	47	35	47	51	63	80	76	64	56.5	62
23	34	33	32	26	34	37	33	43.5	49	41	56	57.5	67	71	69	62	71	77
24	19	17.5	15	20	23	20	30	47	53	46	63	61	60	72	70	64	81	87
25	0	11	9	5	8	9	50	54	54	50	49	44	64	87	82	77.5	85	87
26	10	24	27.5	4	18	17	48	39	32	42	45	45	68	70	80	78	80	79
27	10	15	11	8	27.5	32	24	28	27	42	49	48	55	55	63	57	70	72
28	1	15	17	29	34	35	18	28	27	44	50	49	57	68	71	56	65	63
29	7	21	23	31	27	32.5	20	39	40	48	57	57	57.5	71	75	64	77	83
30	12	26	27	......	......	......	35	48	48	48	54.5	54	62	63	61	69	77	69
31	27	31.5	35	......	......	......	37	38	39	......	......	......	50	54	53	......	......	......
Averages	15.2	20.7	20.1	14.0	19.6	19.1	27.1	33.4	33.2	37	45	44.7	55.3	67.4	66.4	64	73.2	73.6

READINGS OF THE STANDARD AIR THERMOMETER—(*Concluded*).

1904.	July.			August.			September.			October.			November.			December.		
	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.	7 A. M.	12 M.	5 P. M.
1	61	75	67	76	83	85	61.5	71	71	51	52.5	53	47	50	44	23	28	28
2	55	65.5	65	63	75	65	66	81	87	50	55	53	36	53	52	23	24	19
3	57	62	68	64	74	79	69	82	70	42	49.5	48	42	58	51	17	19.5	18
4	64	79	84	65	79	80	60	65	66	42	55	53	43.5	48	44	20	26	23
5	71	62	67	70	84	73	56	67	67	52	61	62	40	37.5	33	25	29	26
6	60	76	72	65	79	80	51	64	63	41	45	43	27	33	32	23	26	26
7	61	72	74	62	72	77	51	69	75	33	45	48	34	37	34	32	34	28
8	68	80	83	61	65	69.5	55.5	63	61.5	43	51	53	27	42	37	30	26	19
9	68	70	74	60	73	75	55	60	61	55	56	53	30	37	37	13	14	10.5
10	69	76	72	66	68	71	59	74.5	72	66	81	76	27	39	31	5	9	10
11	67	80	80.5	65.5	69	68	60	73	75	54	51	50	30	35	34	10	17	17
12	69.5	67	64	63	75	74	61	59.5	63	45	47	43	34	51	47	19	24	24
13	56	67	73	62	76	75	50	65	70	39	45	44	31	40	38	15	15	14
14	60	79	82	63	74	77	67	77	64	41	50	50	34	36	34	13	17.5	12.5
15	68	79	86	63	81	80	50	57	58	33	49	49	33	51	46.5	16	18	14
16	71	82.5	83	65	80	73.5	49	65	67	32	56	56	39	41	37	2	20	20
17	68	80	85	67	78	70	58	72	74	36	65	62	17	32	32	13	20	22
18	76	87	88	60	67	68	63	81	76	59	69	64	30.5	42	43	22	23	22
19	78	90	89	55	71	70	59	68	65	47	66	65	29	52	49	29	36	31.5
20	69	81	78.5	62	73	72	61	70	60	63	62	66	54	59	58	23	24	25
21	65	73	73	64.5	79	80	45	47	44	49	52	51	37	40	35	16	17.5	11
22	64	76	68	71	87	68	39	52	53	46	51	46	34	43	50.5	28	29	32
23	62	72	69	60	72	72	41	60	62	40	42	42	30	47	45	49	52	51
24	64	74	74	60	76	79	56.5	72	69	33	49	49	39	45	36	15	12	9
25	64	76	74	64.5	85	85	62	64	63	45	51	49	30	30	28	6	18	21.5
26	65	79	70	53	65	69	55	62	69	41	42	40	28	27	25	26	29	30
27	65.5	79	74	60	73	76	54	62	60	32	36	32	25	28	22	38	40	43
28	65	70	66	58	76	80	45	63	64	33.5	46	47	16	19	14.5	32	23	22
29	62	71	72.5	66.5	72	68	63	79.5	72	37	58	55	31	38	40	23	23	21
30	63	76	81	54	70.5	65	64	65	60	33	55	36	35	33	30	23.5	34	31
31	71	86	89	53	69	70	......	......	......	23	40	43	......	......	......	34	46	43
Averages	65.4	75.5	75.7	62.6	74.9	74.0	56.2	67	66	42.8	52.7	51.0	33	40.8	38.0	21.4	25.0	23.4

Average Monthly Temperature Since 1882.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1883.........	17.4	22.3	23.6	43.3	52.0	66.6	67.4	65.6	56.3	46.6	39.1	27.5
1884.........	17.6	28.3	29.5	40.7	54.3	67.1	66.5	69.9	65.2	50.5	36.5	27.2
1885.........	20.6	11.4	18.8	41.2	54.3	63.6	69.7	65.0	58.3	49.2	39.3	27.8
1886.........	19.6	22.9	30.2	48.1	55.7	64.0	68.0	67.5	61.8	49.6	36.8	22 2
1887.........	20.2	23.2	26.3	41.1	62.5	65.7	75.6	66.5	57.7	47.0	37.6	27.6
1888.........	16.4	22.8	24.6	40.8	54.3	66.5	66.8	68.0	62.2	43.9	39.4	29.3
1889.........	29.1	18.1	33.9	45.1	58 4	65.3	70.2	66.0	60.5	44.0	40.3	35.2
1890.........	31.2	30.9	28.8	44.2	52.3	67.1	69.5	67.7	60.1	49.3	37.6	21.4
1891.........	25.9	28.3	30.8	45.3	52.0	66.4	66.4	68.5	66.2	48.3	38.4	35.5
1892.........	21.4	25.9	26.5	43.5	52.8	68.6	70.2	69.4	61.2	50.0	35.9	25.2
1893.........	15.5	20.6	29.5	41.1	54.1	68.2	69.8	68.8	58.0	52.0	38.2	27.5
1894.........	29.7	20.6	38.9	44.1	55.5	67.8	74.2	66.8	64.9	52.7	36.0	31.5
1895.........	21.8	16.9	26.9	44.4	59.0	......	......	71.2	61.7	45.4	39.6	31.4
1896.........	22.4	24.1	24.4	49.3	62.0	65.9	71.4	70.0	60.2	56.5	42.9	27.1
1897.........	23.2	26.1	33.8	45.0	55.4	62.3	73.6	67.6	62.3	52.6	39.7	29.2
1898.........	26.2	26.8	.....	43.2	57.0	67.7	74.2	71.0	65.9	52.1	37.9	27.9
1899.........	22.1	20.4	30.4	46.6	57.6	69.5	71.2	71.6	60.6	53.5	38.9	30.0
1900.........	26.0	22.6	23.6	43.5	56.7	68.4	72.6	74.1	66.1	57.9	41.1	28.7
1901.........	26.1	18 5	32.2	46.5	56.9	68.9	76.6	71.0	64.0	51.4	34.3	27.7
1902.........	23.2	22.2	39.5	46.6	56.1	63.2	71.2	67.6	63.6	43.1	46.3	25.7
1903.........	25.7	28.1	42.4	45.9	60.4	63.2	70.8	65.5	64.4	52.5	36.2	23.3
1904.........	18.9	23.1	30.9	41.4	60.3	67.8	70.0	68.2	61.9	48.4	36.9	22.5

SUMMARY OF MAXIMUM, MINIMUM AND STANDARD AIR THERMOMETERS.

	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November.	December.
Maximum	27.1	38.0	38.3	50.6	72.7	79.2	81.1	80.0	72.6	58.0	45.7	29.4
Minimum	10.7	8.2	23.4	32.2	47.9	56.3	58.9	56.3	51.2	38.9	28.1	15.6
Standard, 7 A. M.	15.2	14.0	27.1	37.0	55.3	64.0	65.4	62.6	56.2	42.8	33.0	21.4
Standard, 12 M.	20.7	19.6	33.4	45.0	67.4	73.2	75.5	74.9	67.0	52.7	40.8	25.0
Standard, 5 P. M.	20.1	19.1	33.2	44.7	66.4	73.6	75.7	74.0	66.0	51.0	38.0	23.4

PRECIPITATION BY MONTHS SINCE 1882.

YEAR.	January	February.	March.	April.	May.	June.	u y.	August.	September.	October.	November.	December.	Total.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
1882	....	....	....	....	....	3.69	2.42	2.37	1.25	0.62	1.22	0.55	....
1883	0.48	1.44	0.88	1.58	4.45	4.12	2.98	3.47	2.12	2.10	1.54	0.73	25.89
1884	1.83	2.01	2.54	0.83	2.49	2.01	2.33	1.44	3.17	1.67	1.01	0.97	22.30
1885	1.07	0.61	0.12	1.26	1.58	2.49	4.64	5.02	2.11	2.88	1.36	0.76	23.90
1886	1.13	0.95	1.13	4.13	1.92	2.92	4.41	2.86	2.31	1.79	3.48	1.24+	27.87
1887	0.18	2.97	0.48	1.37	0.46	2.01	6.37	3.03	0.75	1.74	1.58	1.35	22.29
1888	0.78	1.04	1.43	3.09	2.79	3.88	0.99+	4.02	2.73	3.47	2.02	1.24	27.48
1889	2.99+	0.25	0.66+	3.28	1.21	7.47	4.57	1.98	2.50	3.32	3.44	1.62	32.28
1890	2.16	1.45	2.16	2.20	5.49	5.26	1.07	4.34	5.81	4.54	2.40	....	36.88
1891	1.44	1.57	3.25	1.63	0.49	4.31	3.52	3.16	0.47	2.65	0.74	3.29	27.52
1892	0.57	0.88	0.55	0.67	4.04	3.95	1.89	4.77	1.12	1.34	1.67	0.72	23.17
1893	1.62	3.71	1.94	2.59	4.92	3.08	3.68	5.38	2.68	1.59	1.09	1.56	33.84
1894	2.21	2.71	1.36	2.43	7.03	1.77	1.50	1.22	4.64	3.59	0.43	0.47	29.36
1895	0.96	....	0.29	1.36	2.88	....	....	2.66	0.94	0.72	2.31	2.49	....
1896	1.19	2.28	0.84	0.41	2.31	3.71	4.12	3.33	4.27	2.26	2.18	0.71	27.61
1897	0.64	0.21	2.12	1.90	2.19	3.16	5.28	1.27	2.36	0.73	2.53	1.39	23.78
1898	1.74	0.33	1.54	2.03	1.90	2.37	1.32	3.60	1.86	3.83	2.03	0.33	22.90
1899	0.37	0.30	1.22	1.12	1.69	1.71	4.15	1.05	2.23	2.69	1.36	1.46	19.35
1900	1.43	2.42	0.02	0.95	1.71	1.45	6.53	1.75	0.91	3.65	6.13	0.78	27.73
1901	0.72	....	2.19	4.43	3.80	2.07	3.97	5.52	2.46	1.35	2.09	3.37	31.97
1902	0.86	0.66	1.94	1.92	2.84	4.33	5.29	2.41	2.88	2.32	0.74	0.74	26.89
1903	1.81	1.11	5.60	2.60	0.23	7.77	4.86	7.21	1.30	4.19	1.63	0.38	38.69
1904	0.80	1.03	2.41	1.67	4.04	3.37	5.73	2.56	3.26	2.06	0.26	1.42	28.61

PLATE I.—INOCULATED AND UNINOCULATED CABBAGE PLANTS.

AT THE LEFT, A PLANT SUFFERING FROM A SEVERE ATTACK OF BLACK ROT ONE MONTH AFTER INOCULATION WITH *P. Campestris* WHICH WAS ISOLATED FROM CABBAGE SEED HELD IN DRY CONDITION FOR ELEVEN MONTHS; AT THE RIGHT, A HEALTHY CONTROL PLANT

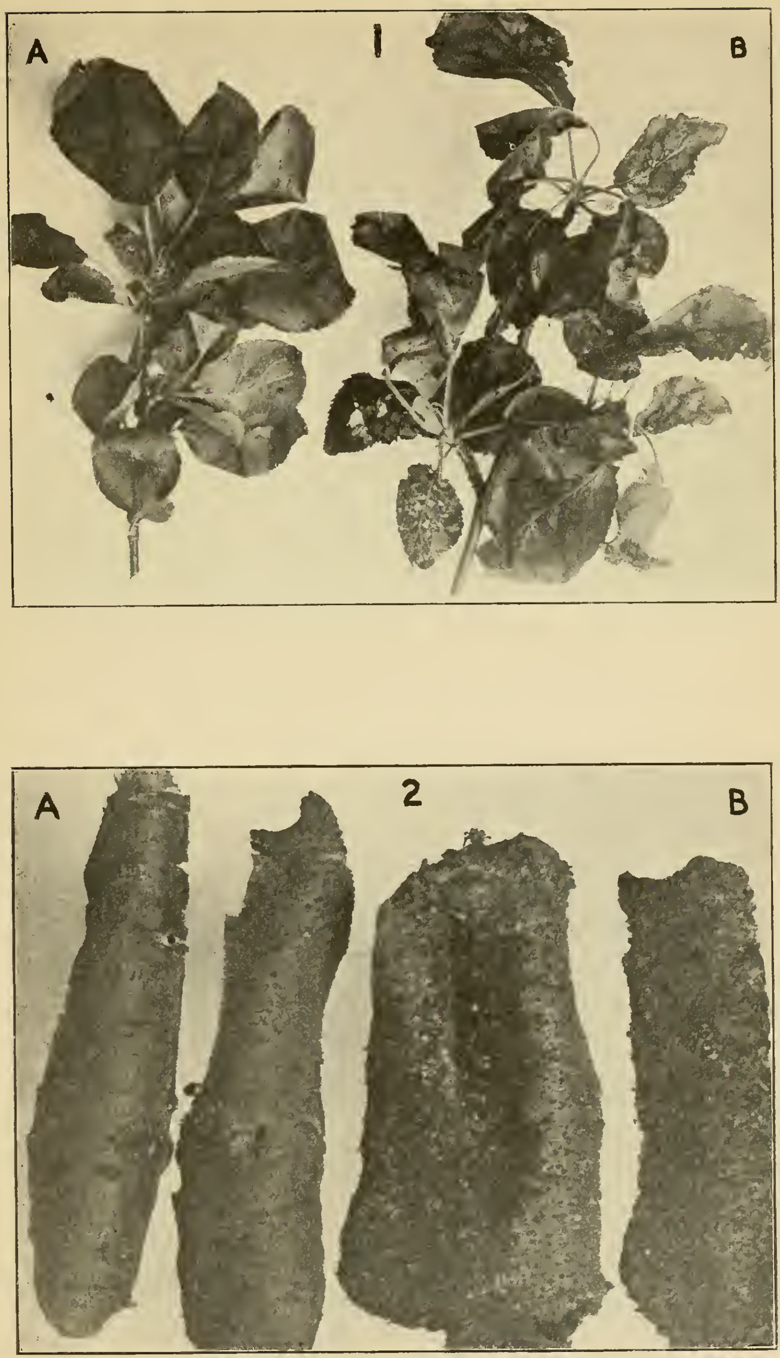


PLATE II.—Effect of lime-sulphur-soda wash on leaf-eating caterpillars and on scales: A, sprayed; B, unsprayed.

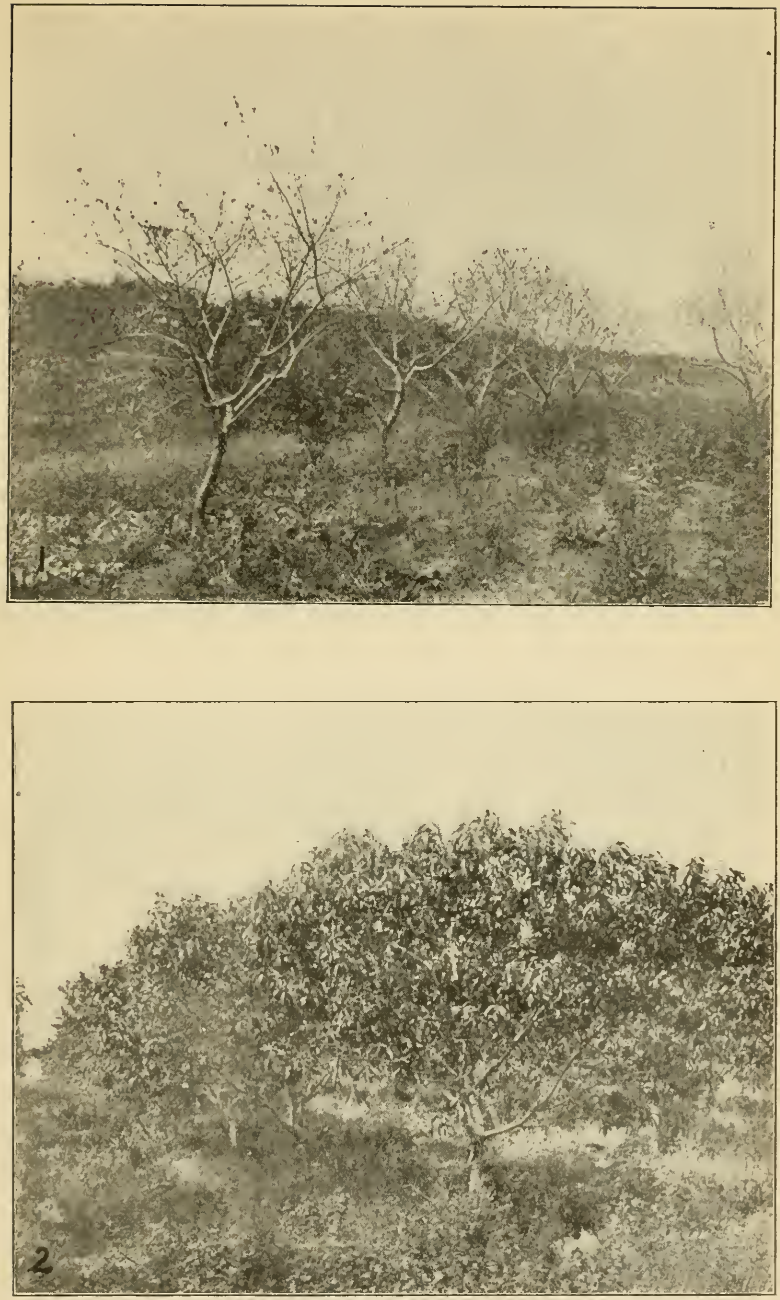


PLATE III.—Effect of lime-sulphur-salt wash on peach leaf-curl and scales: 1, unsprayed; 2, sprayed.

PLATE IV.—Lime-sulphur-salt wash as a preventive of peach leaf-curl: 1, unsprayed Elbertas; 2, sprayed Elbertas.

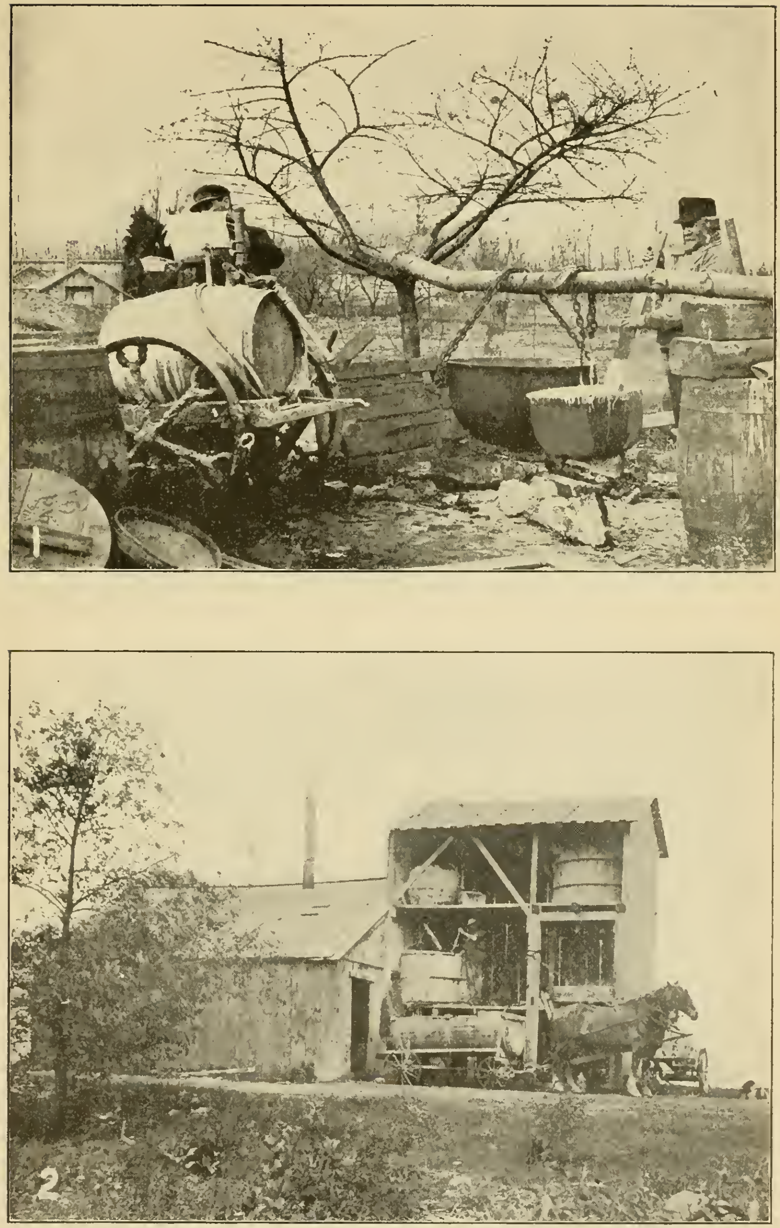


PLATE V.—Preparation of lime-sulphur-salt wash: 1, over wood fire; 2, in popular steam outfit.

PLATE VI.—Effect of fall spraying with sulphur washes on Fitzgerald peaches: upper, boiled lime-sulphur-salt wash; lower, lime-sulphur wash.

Orchard I. Photographed May 31, 1904.

PLATE VII.—Effect of fall spraying with sulphur washes on Fitzgerald peaches; upper, not treated; lower, self-boiled lime-sulphur-caustic soda wash.

Orchard I, Photographed May 31, 1904.

PLATE VIII.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PLUMS; REINE CLAUDE SPRAYED WITH LIME-SULPHUR-CAUSTIC SODA WASH.

Orchard I, Photographed May 1, 1904

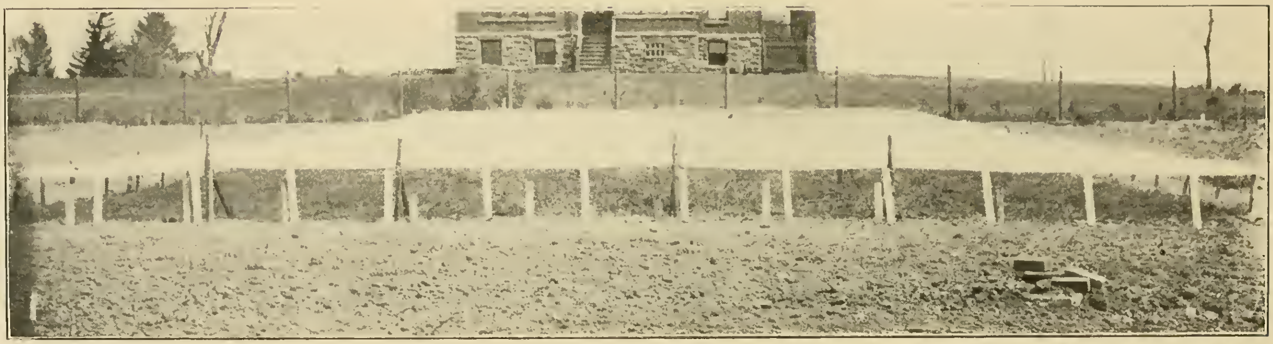
PLATE IX.—Effect of fall spraying with sulphur washes on plums; Reine Claude sprayed with lime-sulphur wash.
Orchard I, Photographed May 1, 1904

PLATE X.—EFFECT OF FALL SPRAYING WITH SULPHUR WASHES ON PLUMS; REINE CLAUDE, UNSPRAYED.
Orchard I, Photographed May 12, 1904.

PLATE XI.—Effect of fall spraying with sulphur washes on plums; Upper, Reine Claude sprayed with boiled lime-sulphur-caustic soda wash; Lower, Burbank sprayed with self-boiled lime-sulphur-caustic soda wash. Rows sprayed with other washes similar.

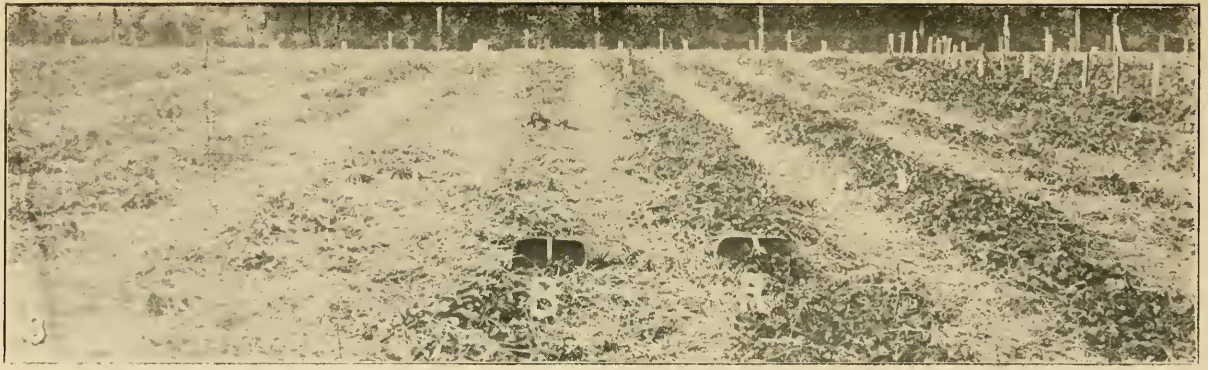
Orchard II. Photographed May 31, 1904.

At Penn Yan.



At Geneva.

PLATE XII.—Strawberry-shading experiments: Covers in position.



UNSHADED PLAT AT GENEVA.

SHADED PLAT AT GENEVA.

PLATE XIII.—HEIGHT OF FOLIAGE NEAR CLOSE OF PICKING SEASON.

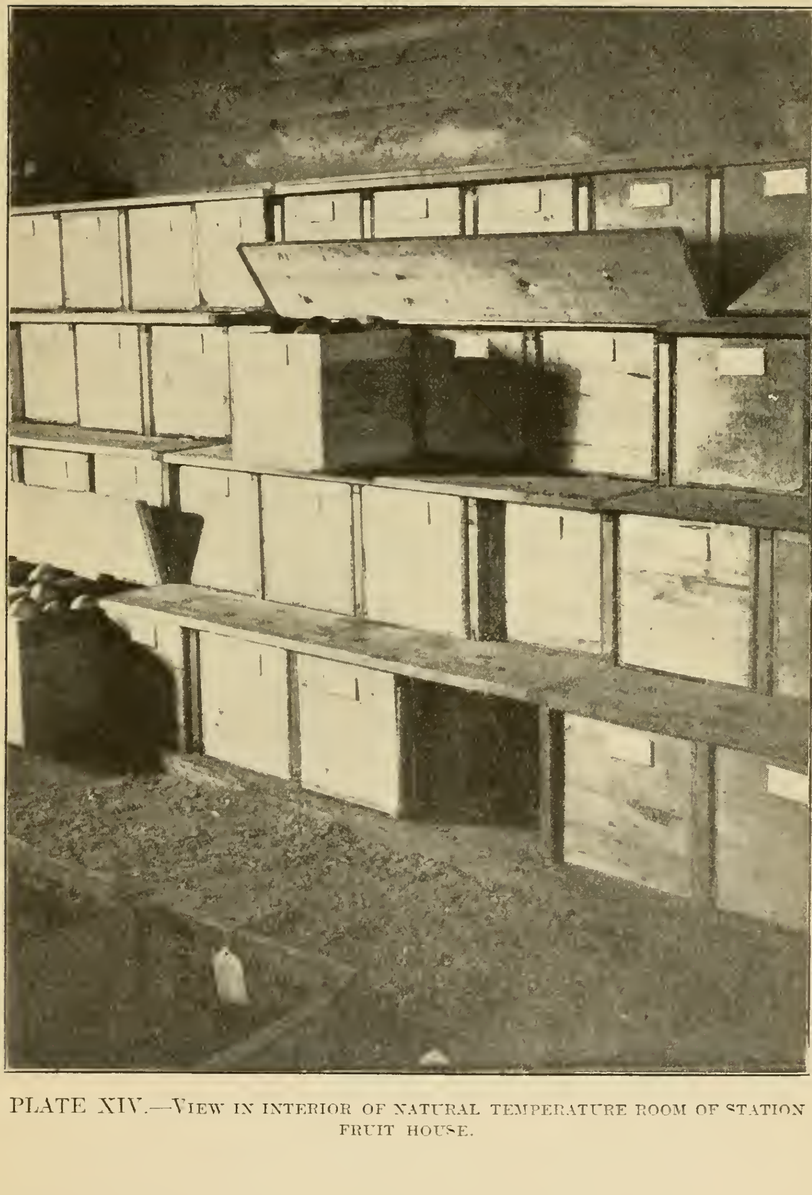


PLATE XIV.—View in interior of natural temperature room of station fruit house.

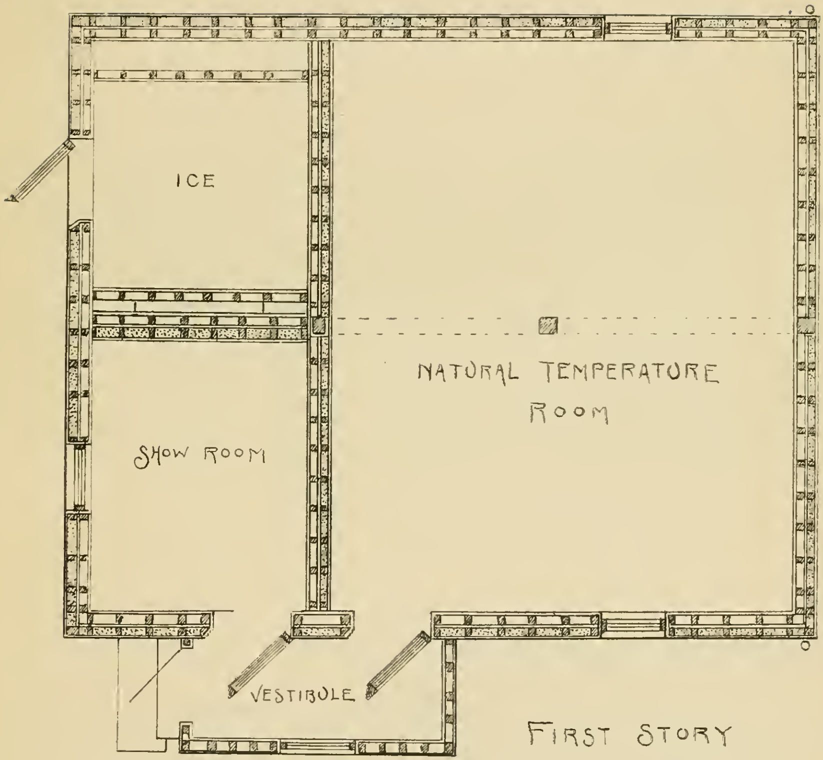


PLATE XV.—First story plan of station fruit house.

Sp. gr. 1.20 1.17 less than 1.00

FIG. 1.—From seed of specific gravity less than 1.20.

FIG. 2.—From seed of sp. gr. 1.23–1.26 (The Optimum).

Sp. gr. 1.35 1.33 1.27

FIG. 3.—The highest ranges in specific gravity.

PLATE XVI.—Cultures of clover from seeds of low, medium and high specific gravity.

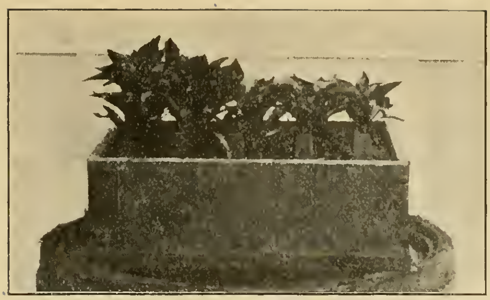


FIG. 1.—Showing unequal vigor of pepper seedlings from seeds of different sizes and colors.

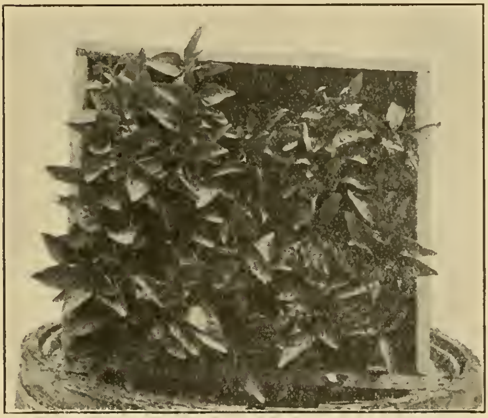


FIG. 2.—Showing unequal germination of pepper seeds of different sizes and colors.

Sp. gr. 1.03 1.03–1.12 1.13–1.15

FIG 3.—Yields of roots from Swedish turnip seeds of different specific gravities.

Plate XVII.

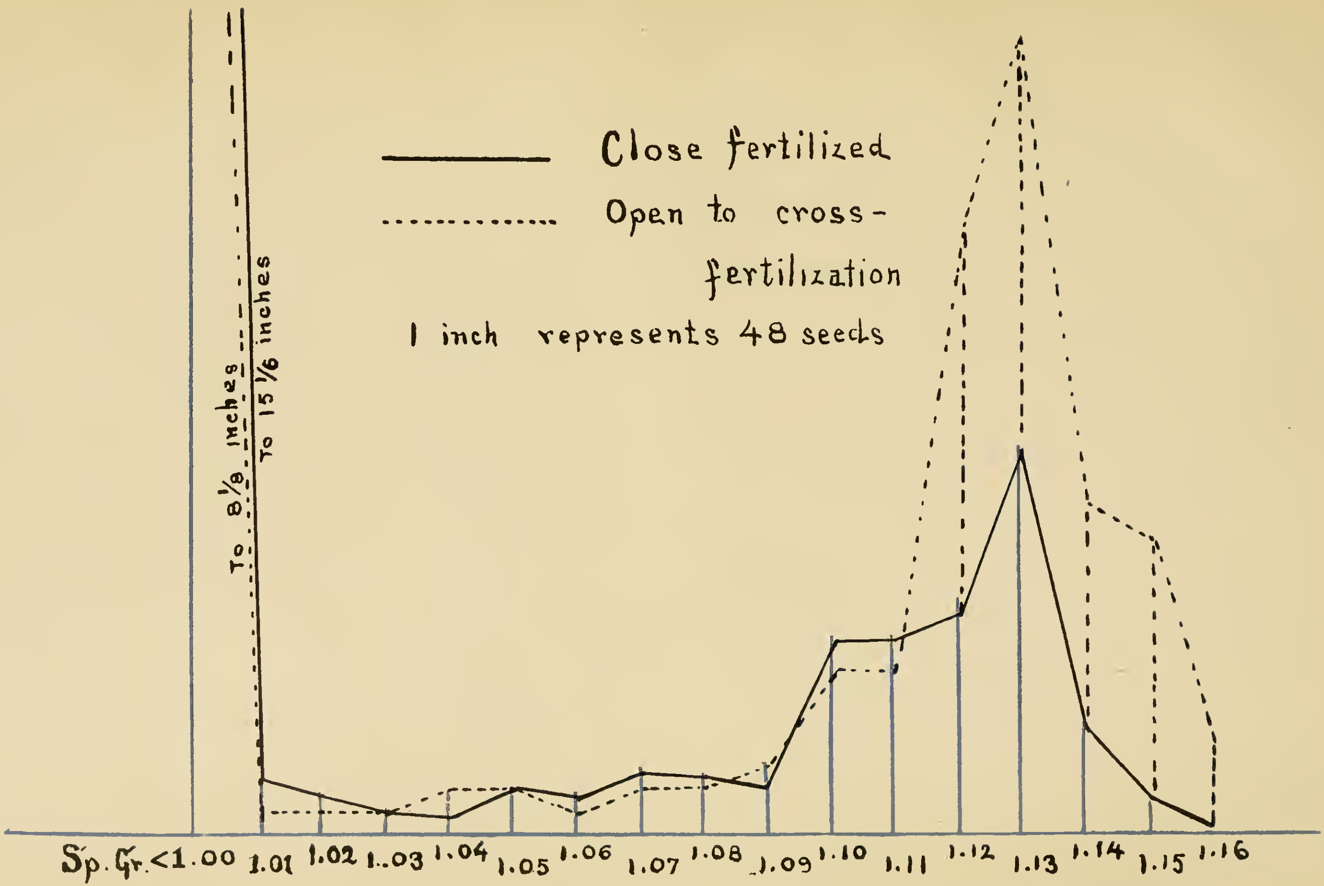


CHART I.—RELATIVE DISTRIBUTION OF LITTLE BLUE GRAPE (HYBRID) WITH REFERENCE TO SPECIFIC GRAVITY.

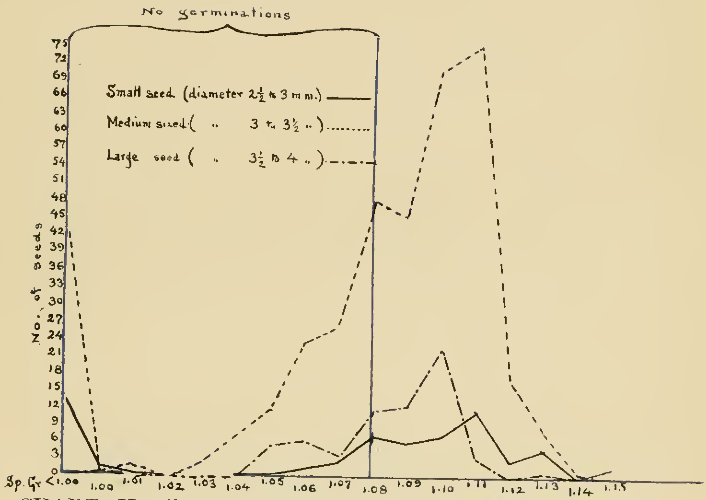


CHART II.—Relative number of small, medium sized and large seeds of Mabel grape, and the relative distribution of each as regards specific gravity.

CHART III.—Percentage distribution of seeds of Mabel grape of different sizes.

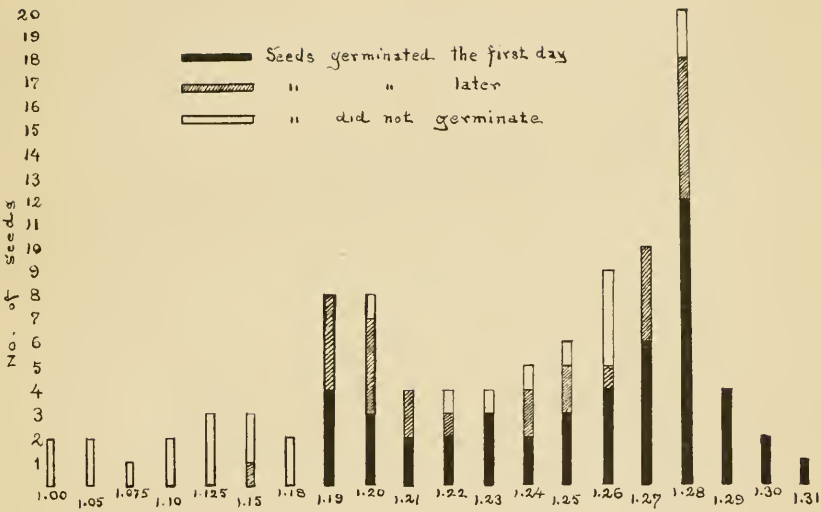


CHART IV.—DISTRIBUTION OF CHAMPION OF ENGLAND PEAS AS REGARDS SPECIFIC GRAVITY, AND RELATIVE NUMBER AND DISTRIBUTION OF SEEDS GERMINATING IN 66 HOURS AND OF THE TOTAL GERMINATION.

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