BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE

No. 51

Contribution from the Bureau of Chemistry, Carl L. Alsberg, Chief.

July 20, 1914.

(PROFESSIONAL PAPER.)

A BACTERIOLOGICAL AND CHEMICAL STUDY OF COMMERCIAL EGGS IN THE PRODUCING DISTRICTS OF THE CENTRAL WEST.[1]

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INTRODUCTION.

The deterioration of eggs between the time of their production on the farm and their arrival at the consumer's table has been discussed from different viewpoints in the publications of the Department of Agriculture. Among these discussions have been the various causes contributing to the loss of freshness, the necessity for lessening the number of eggs that become totally unfit for food each year, the results of improved methods of handling, and the fixing of responsibility for the enormous economic and financial loss due to decay.

The scientific literature on the bacteriology and chemistry of the egg of the domestic fowl is surprisingly meager, considering the many ages that the egg has served as an important article of food. The distinction between a good and a bad egg has rested more often on individual opinion, colored by prejudice or preference, than upon

[1] This report embodies a study of eggs, the first of a series of reports from the investigation of frozen and dried eggs, which is being conducted by the Food Research Laboratory of the Bureau of Chemistry. It deals with the subject of the quality of the eggs which go to the egg-breaking establishments in the egg-producing sections of the Central West. It is the basis on which the study of industrial problems and conditions must be founded. The second report of the series will deal with the commercial procedures in the packing houses, the environment, and methods of work which must be followed if a high-quality product is to be produced. Other phases of the investigation will be embodied in reports on the general management in the packing houses making for efficiency, and on the treatment which the output receives in the establishments of the bakers, who are the chief users of frozen and dried eggs. For the data submitted we are indebted to M. K. Jenkins, who has studied a number of individual eggs, prepared the "commercial" samples, and has been of very material assistance in the correlating and presenting of the facts; to E. Q. St. John, who has done the greater part of the bacteriological work; and to W. B. Hicks, who is chiefly responsible for the chemical analyses. The Omaha Food and Drug Inspection Laboratory, with its force of chemists, in charge of S. H. Ross, was assigned to this investigation with the staff of the Food Research Laboratory for the summers of 1911 and 1912, and was made the headquarters for the field investigations.

NOTE.—This bulletin gives details of an extensive study of commercial eggs and makes recommendations for improvements in handling. While the study was made in the Central West, the bulletin is equally of interest to all sections where eggs are produced in commercial quantities and are sent to egg-breaking or other packing establishments.

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the exact knowledge of the composition or history of the egg itself. The farmer's wife, accustomed to the fresh eggs of the farm, discards as unfit for food an egg which the city baker would, with a clear conscience, serve to his own family. The difference in the point of view has progressed even to the savants who have held opposite and positive opinions concerning the wholesomeness or desirability of certain eggs, especially of those known in commerce as "frozen" or "desiccated."

Investigation has shown that when the egg is laid it is of a fairly constant chemical composition and contains but few bacteria or molds. In the vicissitudes of marketing, with its attendant undesirable conditions, eggs in the shell undergo a variety of changes, referable, almost exclusively, to the mode of handling. These changes, their effect upon the food and market value of the egg, and the means by which they can be reduced to a minimum have been, and still are, a subject of investigation by the Department of Agriculture cooperatively with every branch of the egg-marketing industry.

The great variety of conditions to which an egg is subjected and its sensibility to temperature, humidity, odors, etc., result in many evidences of deterioration in the eggs on the market. The extent to which such downward changes are reflected in the composition of the egg, together with their recognition by physical, chemical, and bacteriologic methods, is the subject of the present report.

The work has been done as part of an investigation of the preparation of frozen and dried eggs. It is the foundation on which to build all the other phases of the investigation, such as the construction of the apartments in which egg breaking for food purposes can proceed; the methods used to guard against bacterial contamination; the systematic application by the employees in the packing houses of the knowledge gained by scientific research to increase accuracy and efficiency; the quality of the output of the houses under old and new conditions, and the behavior of those products when they reach the hands of the baker, who, for this investigation, may represent the consumer. These diverse parts of the work will be reported in a series of publications of which this is the first. It will be observed, therefore, that the subject is discussed from the industrial viewpoint, even though it is essentially a laboratory study.

The individual eggs, and some of the composite egg samples, were opened in the laboratory; the samples designated "commercial" were opened by a bacteriologist in packing houses where the surroundings were as clean as, or cleaner than, in the laboratory and where all utenstils were sterilized.

The information given in this report has been gathered in southwestern Iowa, northern Tennessee, and the valley of the Missouri from the northern border of Iowa to the central part of Kansas.

The eggs were from sources comparatively close to the investigators; that is, the haul was seldom more than 200 miles. Had the eggs not been broken at these first, or, at most, second concentrating centers, the probability is that they would have been shipped a four to seven days' haul before reaching a consuming center. They were, therefore, in a correspondingly better condition because broken nearer their point of origin. The field work reported was carried on during the summers of 1911, when exceptionally hot weather prevailed over an unusually wide territory, and 1912, which was not an unusual summer in any respect. The individual eggs, however, were studied between the winter of 1910 and the autumn of 1912.

To comprehend the egg on the market it is necessary to determine first the condition of the absolutely fresh egg, that a standard of comparison may be obtained, and then the condition of the eggs on the market to see wherein and how much they differ from the fresh article. It is also highly desirable to observe the character of the eggs bought by the housewives at the corresponding time, in the same locality, to see whether there are any material differences between the eggs broken for home cookery and those broken by the egg canner who supplies the public baker.

FRESH EGGS.

BACTERIAL CONTENT.

The chemical and bacteriological characteristics of perfectly fresh eggs—that is, eggs which are not more than 24 hours old and which are kept in a cool place—have been given by the first author of this report in a previous communication, entitled "A Chemical and Bacteriological Study of Fresh Eggs."[1] In this study 150 high-quality eggs, not more than 24 hours old, were examined for the bacterial content in white and yolk. A strictly fresh egg is pictured in Plate I (see at end of this bulletin). Aseptic precautions were used in obtaining samples and all the work was done on the basis of weight, not volume, since the latter introduces a decided error in so viscous a substance as egg. A summary of the results shows that there was found an average of 2 organisms per gram in the white and 6 per gram in the yolk when the incubation temperature was 37° C., and 7 organisms per gram in the white and 9 per gram in the yolk when the incubation was at 20° C. It may be said that these eggs were gathered between February and November, inclusive.

Stiles and Bates,[2] in a recent study of 616 fresh eggs gathered between April and October, found that the average infected yolk contained 271.7 organisms to the cubic centimeter and the infected white 15.9 organisms. They also found, however, that in 13.99 per

[1] J. Biol. Chem., 1910, 7 (2) : 109.

[2] A Bacteriological Study of Shell, Frozen and Desiccated Eggs Made Under Laboratory Conditions. U. S. Dept. Agr., Bureau of Chemistry Bul. 158, 1912.

cent of the yolks examined there were no organisms present in 1 cc of the material, and the white of the egg was sterile in 1 cc quantities in 32.18 per cent of the samples examined. Maurer[1] reported 81.9 per cent of the eggs he examined to be sterile, and stated that of the 18.1 per cent infected 82 per cent were infected in the yolk, 25.9 in the white, and only 7.9 per cent in both yolk and white. Maurer used aseptic precautions in obtaining samples of the egg material examined. Stiles and Bates did not clean the shells, and their method of opening was to crack on the edge of a sterile Petri plate and shift the yolk from shell to shell in housewife fashion, to effect a separation of the two substances. The plate used for cracking the shell was also the container of the sample. Maurer does not give the number of organisms occurring, merely stating their presence or absence.

The bacterial content of fresh eggs has been proved to be widely diversified in the character of the organisms present, but their numbers are small. The varieties of organisms present will be considered elsewhere. It may be said, however, that Pennington[2] did not find *B. coli* in any of the 150 eggs examined; neither did Maurer in a study of 160 eggs, many of which had dirty shells or were placed under artificial conditions favoring shell penetration. *B. coli* were found on the shells in many cases. Stiles and Bates found one egg laid in the month of July that contained *B. coli* in the yolk. It is possible, however, that this might have been the result of contamination while cracking on the edge of the Petri dish or separating white and yolk by the shell method of the housewife. With the exception of this one egg yolk wherein *B. coli* were reported, the examinations of fresh eggs do not, from a practical industrial viewpoint, show conflicting testimony. They agree fairly well in asserting that the fresh, well-handled egg, though not always sterile, is not, on the other hand, infested by large numbers of bacteria, and *B. coli* are practically never present.

After bad handling or mistreatment the number of organisms may, and frequently does, increase enormously. Whether they invariably appear in numbers after bad handling or age has interfered with the integrity of some one or more of the component parts of the egg is a problem to be solved. The studies here chronicled are expected to throw some light on this question. Such studies would indicate also whether the large numbers of bacteria found in certain eggs are due to a rapid increase of the original organisms found in them even while still present in the oviduct, or whether an additional infection through the shell is common in the course of the usual routine of marketing.

[1] Bacteriological Studies on Eggs. Kansas State Agricultural College Bul. 180, 1911.
[2] J. Biol. Chem., 1910, 7 (2) : 109.

CHEMICAL COMPOSITION.

Numerous chemical analyses of fresh eggs have been made in this laboratory in connection with the investigation of the handling of eggs. They extend our knowledge of the composition of the fresh egg, especially in relation to the quantity of loosely bound nitrogen in egg protein; that is, the nitrogen split by the action of a weak alkali and removed for estimation by aeration. This form of nitrogen occurs in very minute quantity in the protein of the freshly laid egg, and is much increased, though still small in amount, in eggs that have deteriorated. The amount of loosely bound nitrogen is at the present time the best and simplest index that has been found of the chemical stability of the egg. Hence the quantity of this substance has been determined in the various grades and kinds of market eggs and in those used by the egg breakers, as well as in eggs 24 hours old.

The analyses recorded in Table 1 show that most of the loosely bound nitrogen is found in the yolk of the egg, where it averages in western summer eggs of highest quality 0.0023 per cent. Whole eggs of like grade gave 0.0013 per cent as an average.

TABLE 1.—*Fresh eggs.*

Portion and sample No.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Gelatin liquefying organisms per gram.	Ammoniacal nitrogen, Folin method.		Moisture.	Ether extract.	Size of sample.
		20° C.	37° C.		Wet basis.	Dry basis.			
					Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Eggs.*
White:	1911.								
261	July 14				0.0004	[1]0.0033			18
271	July 17				.0003	.0025			12
557	Aug. 21				.0004	.0033			12
559	...do				.0003	.0025			12
561	...do				.0003	.0025			12
Yolk:									
214	July 10	150	360	130	.0026	.0050	47.81	31.87	6
266	July 14				.0025	.0047	46.88		18
270	July 17				.0023	.0043	46.89		12
556	Aug. 21				.0024	.0046	47.80		12
558	...do				.0020	.0034	47.28		12
560	...do				.0022	.0042	47.84		12
Whole egg:									
126	June 26	0	5				73.19	10.86	30
127	...do	0	0				73.44	11.28	30
168	July 3	150	70				72.96	11.40	36
212	July 10	75	70		.0013	[2].0047			6
262	July 14				.0011	.0040			
272	July 17				.0013	.0047			11
273	...do	7	0						6
329	July 24	45	50		.0015	.0054			
330	..do	85	45		.0013	.0047			
445	Aug. 4				.0011	.0040			24

[1] Moisture content of fresh egg white taken as 87.94 per cent, average of 236 eggs.
[2] Moisture content of fresh whole egg taken as 72.44 per cent, average of 9 eggs (analyses given in König, pp. 98 and 1470, and of three analyses Nos. 126, 127, and 168 given above).

A number of unpublished analyses of fresh eggs from various sources would indicate a maximum and minimum variation of 0.0010

and 0.0015 per cent nitrogen, respectively. The analyses of summer eggs made in the western egg-producing district are comparatively few, but since their composition proved to be like that of the eggs studied in the general egg-handling investigation it was not deemed necessary to multiply them beyond the number needed to confirm existing data.

The moisture content of the summer egg is of interest. It may be that there is a relation between the amount of water present in the egg and its resistance to decay. A study, in another connection, of perfectly fresh eggs from a well-cared-for flock during different seasons, when the fowls showed physiological variations, is given in Table 2.

TABLE 2.—*Water content of fresh eggs.*

Date.	Number of samples.	Individual eggs.	Moisture.	
			White.	Yolk.
			Per cent.	*Per cent.*
Feb. 18 to Mar. 16	7	181	87.90	47.44
Aug. 5 to Sept. 17	8 whites... / 7 yolks....	183	88.19	47.96
Oct. 5 to Nov. 2	4	54	87.99	47.54

It will be seen that in August and September, when the industry considers the quality of the eggs lowest, the maximum quantity of water is found in both white and yolk. In the early spring, when eggs are undoubtedly of highest quality, the water content is lowest, and in the cool days of autumn it occupies a medium position. The statement of the increased water content of summer eggs is not made authoritatively, but only as a promising line of investigation on this subject. It can be emphatically stated, however, that analytical differences in tenths of per cent may, in so specialized a tissue as an egg, carry with them marked variations in physiologic functions and chemical stability.

The fat of an egg is almost exclusively in the yolk. According to Pennington[1] the ether extract of the yolk varies from 33.33 to 31.44 per cent, the average for 236 eggs examined being 32.68 per cent.

"MARKET FRESH" EGGS.

The eggs from which the preceding information was obtained can not be accepted as either a standard or an index of the eggs supplied to the people for food, because modern conditions of living and sources of food supplies make it impossible to furnish the market with eggs of uniform quality and minimum age. It is necessary, therefore, as already stated, to study the common market grades of shell eggs accepted by the housewife and compare these with the

[1] Loc. cit.

absolutely fresh eggs, as well as with the eggs put up for bakers' use. Accordingly, ten open-market purchases were made of eggs as they went to the consumer, and analytical data and candling records obtained, using the same method as in the case of the fresh eggs. The results are given in Table 3.

TABLE 3.—*Eggs from grocery store.*

Sample No.	Date of collection.	Cost per dozen.	Sold for—	Ammoniacal nitrogen (Folin method), wet basis.	Size of sample.	Description of sample under candle.
	1911.			*Per cent.*	*Eggs.*	
589	Aug. 25	$0.25	"Strictly fresh eggs" carton packed.	0.0011	24	Fresh.
590	...do	.20	"Good eggs"	.0018	24	Seconds.
591	...do	.20	.....do	.0014	24	Mixed firsts and seconds.
592	...do	.20	.....do	.0014	24	4 shrunken eggs, 5 very stale eggs, 1 blood ring.
636	Sept. 5	.25	"Strictly fresh eggs" carton packed.	.0010	24	
637	...do	.20	"Good eggs"	.0014	24	5 seconds.
638	...do	.20	.....do	.0022	24	22 stale eggs.
639	...do	.15		.0021	12	9 stale eggs, 1 hatch-spot egg, 1 blood ring.
640	...do	.20	"Fresh eggs"	.0013	.....	5 slightly heated.
	1912.					
	June 19	.175	Dirty eggs	.0010	8	Fresh.

Bacterially these eggs did not differ from the strictly fresh eggs. According to the content of ammoniacal nitrogen they varied from absolutely fresh to the usual stale, but not rotten, eggs. The price usually, but not invariably, was in accord with the quality. The carton-packed eggs were individually marked with the sign of the producer, who had a reputation for quality to maintain.

RELATION BETWEEN BACTERIAL MULTIPLICATION AND CHEMICAL CHANGES.

Experiments have shown that evidences of bacterial decomposition can not be recognized by the sense of sight and smell until the organisms have increased enormously in the food substance.

There is an interesting problem involved in the study of the relation between bacterial multiplication and chemical evidences of the metabolic and catabolic changes that must accompany life processes. Bacteria to the number of millions per gram have been considered evidences of an altered chemical composition. Yet more recent observations would indicate that, for certain substances at least, the number of organisms must approach the 100 million per gram mark before the analytical methods for the detection of substances indicative of bacterial life can be applied satisfactorily. Such, for example, has been the finding of Hastings, Evans, and Hart,[1] who have studied

[1] Wisconsin Agricultural Experiment Station Research Bul. 25.

the relation between bacterial multiplication and the formation of lactic acid in milk; Burri and Kursteiner[1] state that the lactic-acid organisms of milk may increase to 100 millions per cubic centimeter before there is a definite rise in acidity. The same observation has been made by Pennington[2] and associates when investigating the decomposition of chicken flesh. In connection with this last study it was found that a marked rise in the ammoniacal nitrogen content of the flesh did not appear when the bacterial counts indicated a few million organisms per gram, but at the next examination, when the count was usually in the hundreds of millions, a rise was commonly found. The principles observed by the investigators cited are corroborated by the results of the study of bacterial content and chemical changes in eggs.

Not until chemical analyses show an increase in the ammoniacal nitrogen are the senses able to detect infected eggs readily. Studies discussed in detail in another section of this bulletin (p. 73) showed that sour eggs which in the early stages are, with difficulty, detected by the sense of smell, and eggs with light green albumen, which are recognized by careful scrutiny, contain bacteria in many millions.

Eighty commercial samples which contained organisms capable of producing gas from lactose in the presence of bile salt were examined for *B. coli*, as described in the chapter on laboratory practice (p. 76).

A portion from each of the higher dilution fermentation tubes, which showed gas, was plated on Endo's medium, or on lactose litmus agar, and from each plate having typical coli-like colonies several were selected for examination.

Organisms conforming strictly to the definition for *B. coli communis*, in the 1905 report of the American Public Health Association on Standard Methods of Water Analysis, were isolated from 55 per cent of the samples examined. Probably 15 per cent more contained organisms which would be classed as typical *B. coli* by a majority of observers because they differed very slightly from the definition just given. In the remaining 30 per cent of samples, which were not found to contain typical *B. coli*, the predominating gas-producing organism was *B.* (*Lactis*) *aerogenes*. Of the typical *B. coli* organisms examined 81 per cent produced gas from sucrose. Practically all of the organisms examined would be classed as members of the *Colon aerogenes* group. If gas production from various sugars is sufficient to distinguish between varieties of these organisms, a very large number of varieties were isolated. Some of them differed from any at present described in the literature.

[1] Centralbl. Bakt., 1911, 2. abt., 30: 241.
[2] U. S. Dept. Agr., Bureau of Chemistry Cir. 70.

A detailed study of the organisms isolated is now in progress in this laboratory. A special report will be issued dealing with this phase of the work.

EXAMINATION OF EGGS OPENED ASEPTICALLY IN THE LABORATORY.

Because of the great diversity of conditions to which an egg in the shell may be subjected, the corresponding variety in the results which may follow, and because each individual egg must be considered as an individual by the candler and the egg breaker, even though its individuality is finally lost in the mixing, drying, or freezing of the commercial product, the study to be reported here had to deal first with single eggs of the various types found in commerce and which may or may not be used by the breaker in his output intended for food.

Tables 4 to 13 give the bacterial content of 300 individual eggs and 26 small samples, aggregating 981 eggs, classified in accordance with their most important or striking characteristic or the one probably responsible for the condition of the egg when it was examined. For example, an egg might show a heavy, settled yolk in a sound, clean shell, in which case it would be found in Table 5, under the heading of "Individual eggs with settled yolks." But if that egg, in addition to the settled yolk, had a dirty or cracked shell, it would be classed in Table 7 or Table 8, devoted to dirty-shell eggs and cracked-shell eggs, respectively.

The eggs were examined by means of a candle and their appearance described before the contents of the shell were studied bacteriologically. The classification of the eggs was made on these observed characteristics, and on others noticed when the shell was broken, rather than on the bacterial condition revealed by the laboratory work. The history of these eggs was known only in a very few instances. None of them were "market firsts," or high-class eggs, when they were received.

The study of the individual egg is logically followed by a study of a number of eggs which are similar when graded by means of the candle and by the characteristics observed on opening. Such samples of like eggs, aseptically opened, follow the report of the individual eggs in a number of the tables. The technique used is described on page 74. The samples were analyzed for the amount of loosely bound nitrogen they contained, as well as for the number of organisms.

STALE EGGS.

A very large proportion of the eggs going to the breakers are simply stale; that is, the shell shows an enlarged air space, the yolk has gained in opacity and definiteness of outline, and it is com-

monly either above or below the normal meridian position. (See Pl. II.) The white is frequently thin, and many times rough handling, combined with other age-accentuating conditions, have so separated the membrane lining the shell from the membrane inclosing the egg proper that the form and position of the air space can change as the egg is turned. This appearance has caused the trade term "weak eggs" or "watery eggs." But because these terms are loosely used and have several meanings in different sections of the country, or among different candlers, such conditions are characterized in this report as "movable air cells," this term actually describing the change which has occurred.

In the late summer and autumn, when the lay has fallen off and the country merchants are withholding stocks for coming high prices, such eggs form a very large proportion of the current receipts of the cities and are, of necessity, used by all of the community who depend upon such sources for their egg supply.

When warm weather prevails many of these stale eggs show what is termed "heat"; that is, the yolk rises in the shell and is flattened, the white becomes thinner than normal, and the air space increases in size. These changes, well shown in Plate II, take place in fertile and infertile eggs, both of which become distinctly stale if kept sufficiently long. In the fertile egg, however, there comes a second series of changes, namely, incubation, which, in the very earliest stages after the egg is laid, can not be distinguished by the candling method, but has as one of its accompaniments the rising of the yolk to the upper part of the shell. When the shell of a "heated" egg is broken the germinal spot, if fertile, is seen to be slightly thickened. In an infertile egg the germinal spot is seen with difficulty. Such eggs, whether fertile or infertile, are good in appearance, odor, and taste, but deterioration is rapid and they will not stand long hauls to market nor keep well in cold storage. Hence, such eggs are used in the egg-breaking plants. Their bacterial content is shown in Table 4, where it will be seen that the bacteria are either very few or entirely absent, and that, bacterially, at least, these eggs are not to be distinguished from eggs just laid.

TABLE 4.—*Stale eggs.*[1]

INDIVIDUAL EGGS.

Sample No.	Date of examination.	White. Total number of bacteria per gram on plain agar. Incubated at 20° C.	White. Incubated at 37° C.	Yolk. Incubated at 20° C.	Yolk. Incubated at 37° C.	Number of gas-producing bacteria per gram in lactose bile. White.	Yolk.	Description.
	1911.							
3023–1	Mar. 28	0	0	0	0	.....	.....	
3023–2	...do.....	0	0	0	0	.....	.....	Slightly dirty shell.
3023–4	...do.....	5	0	5	0	.....	.....	Clean shell.
3024–7	Apr. 4	0	5	10	0	.....	.....	Clean-shelled guinea egg kept in cold storage 1 year and in candling room 1 week.
3026–1	Apr. 7	10	0	.....	0	.....	.....	Clean shell, slightly shrunken, small hatch spot and floating yolk.
3026–7	...do.....	20	0	10	0	.....	.....	Clean shell; slight shrinkage.
4005	June 12	0	20	0	0	0	0	Weak white and yolk, hatch spot not enlarged, movable air cell.
4039	July 8	0	0	0	0	0	0	Clean-shelled, fresh infertile egg, kept at room temperature for 8 days. Weak white and yolk, marked shrinkage, slightly movable air cell.
4040	...do.....	0	0	0	0	0	0	Clean-shelled, infertile egg, kept at room temperature for 8 days. Watery white, marked shrinkage, slightly movable air cell.

[1] Samples 3001 to 3031, inclusive, were examined by Christine S. Avery.

SMALL COMPOSITE SAMPLES.

Sample No.	Source.[1]	Date of examination.	Total number of bacteria per gram on plain agar. Incubated at 20° C.	Incubated at 37° C.	Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen (Folin method). Wet basis.	Dry basis.	Per cent of moisture.	Description.
		1912.							
4579	D 3	June 19	0	0	0	0.0017	0.0061	72.13	63 eggs; small, most of them shrunken.
4630	E 4	June 28	50	200	0	.0018	.0064	72.02	66 eggs; shrunken.
		1911.							
296	B	July 19	600	2,400	0	.0016	.0069	.....	8 eggs; shrunken.

[1] See p. 40.

Even when 5 dozen or more such eggs are mixed together the bacterial findings for the individual of the type hold good. The loosely bound nitrogen in these samples of "stale" eggs is the same as, or a little less than, that found in the "grocery" eggs purchased in the open market during the summer of 1911.

EGGS HAVING SETTLED YOLKS.

Table 5 shows another type of deterioration, which is further advanced and more specific than that meant by the general term "stale." The yolk has become more opaque and consequently clearer in outline when viewed by the aid of the candle and has fallen to the pointed end of the shell (see Pl. III), where it turns sluggishly when rotated. Very frequently when these eggs are opened the yolk is seen to have a very thin, weak membrane. During warm weather, when incubation goes on almost continuously, though very slowly, these eggs with settled yolks frequently show a germinal area about one-fourth inch in diameter, having a visible white line through their center—the "primitive streak" of the embryologists. (See Pl. II.) Their odor is generally good and their taste not objectionable, except for soft boiling or poaching.

TABLE 5.—*Individual eggs with settled yolks.*

Sample No.	Date of examination.	White.		Yolk.		Whole egg.	Number of gas-producing bacteria per gram in lactose bile.		Description.
		Total number of bacteria per gram on plain agar.							
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 37° C.	White.	Yolk.	
	1911.								
4004	June 12	70	0	.....	.....	.....	0	.....	Watery white.
4013	June 13	0	0	30	0	.....	0	0	Enlarged hatch spot; bloated yolk.
4014	...do.....	0	0	20	0	.....	0	0	
4015	...do.....	30	0	20	10	.....	0	0	Enlarged hatch spot.
4016	...do.....	20	0	40	0	.....	0	0	Enlarged hatch spot; bloated yolk.
4018	...do.....	0	0	30	10	.....	0	0	
	1912.								
41089–7	Aug. 31	.....	.....	.....	.....	64,000	.....	.....	Marked shrinkage.
41089–8	...do.....	.....	.....	.....	.....	[1]0 at 100	.....	.....	Very weak yolk which broke when egg was opened.
41089–12	...do.....	.....	.....	.....	.....	54,000	.....	.....	
41089–18	...do.....	.....	.....	.....	.....	240,000	.....	.....	Marked shrinkage.
41089–19	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage; yolk broke when egg was opened.
41089–21	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage.
41089–27	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Decidedly weak yolk which broke when egg was opened.
41089–28	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage.
41089–33	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–38	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–39	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage; yolk broke when egg was opened.
41089–41	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage.
41089–42	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–44	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage; yolk broke when egg was opened.
41089–45	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–46	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–50	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage.
41089–53	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–55	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–57	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–58	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–59	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Do.
41089–61	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Yolk broke when egg was opened.
41089–62	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	Marked shrinkage.
41089–63	...do.....	.....	.....	.....	.....	0 at 100	.....	.....	

[1] 0 at the dilution given indicates that no organisms were observed on the plate.

The bacterial content of these eggs is generally slightly higher than in the earlier stage of staleness unless aging has occurred at the low temperatures of the egg storage warehouse, when the count is as low as or lower [1] than in new-laid eggs.

This type of deteriorated egg is very common in the breakers' stocks, and, indeed, throughout the market seconds in both summer and winter, due to rapid deterioration from high temperatures in the one case and to the slow deterioration which occurs at 29° to 31° F. in the other. The market life of such eggs is shorter than when deterioration is not so far advanced. Hence the egg shipper with a breaking establishment at hand prefers to break and freeze or dry these eggs while they are still edible rather than to risk the certain losses of a haul to the consumer.

EGGS CHANGED BY INCUBATION.

Table 6 shows typical bacterial findings in eggs where deterioration had progressed along different lines than those described under stale eggs and eggs with settled yolks. In the first group of 20 eggs the development of the chick had not reached the blood-forming stage, which normally occurs in about 24 hours when the temperature is that of the hen, 103° F., but which had gone sufficiently far for the candler to observe a small darkened area on the yolk. This in the industry is known as a "light spot," and when the egg is broken it is usually seen as a round area about three-eighths inch in diameter, having two distinct zones, an inner and outer circle (see Pl. II). Such eggs, constantly sold in their shells for food purposes, are used by the housewife without question if the odor is good and if the white and yolk are intact. They do not ship well because the yolk membrane is often weak, and many kinds of spoilage may develop in them on short notice. Hence they are sent in large numbers to the egg breakers in the producing regions.

[1] Unpublished results on storage eggs.

TABLE 6.—*Eggs changed by incubation.*

INDIVIDUAL EGGS SHOWING HATCH SPOT.

Sample No.	Date of examination.	White.		Yolk.		Whole egg.		Number of gas-producing bacteria per gram in lactose bile.			Description of sample.
		Total number of bacteria per gram on plain agar.									
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Whole egg.	
	1910.										
3006–1	Jan. 20					0	41				
3008–1	Jan. 23					39	13				
3008–3	...do					38	230				
3009–3	Jan. 27	7	0								
3009–4	...do	11	11								Small hatch spot; slightly dirty shell; some shrinkage.
	1911.										
3024–1	Apr. 4	4	75								
4006	June 12	0	20	0	0			0	0		Fixed air cell.
4038	July 8					0	0	0	0		Very movable air cell.
4057	July 13	0	0	260	30			0	0		Good odor; watery white; marked shrinkage; movable air cell.
397	July 31					10	10			0	
398	...do					85	10			0	
399	...do					20	5			0	
400	...do					75	20			0	
401	...do					20	15			0	
4061	Sept. 5	590	340		90			0	0		Hatch spot size of a dime; good odor on opening; firm white; marked shrinkage; broken air cell.
4065	...do	90	0	30	0			0	0		Very large hatch spot; good odor upon opening; fairly clean; marked shrinkage; broken air cell.
4076	Sept. 14	30	0	25	150			0	0		Hatch spot size of dime; good odor on opening; weak white and yolk; clean shell; marked shrinkage; broken air cell.
4077	...do	30	40	0	0			0	0		Large hatch spot; good odor on opening; weak white and yolk; clean shell; marked shrinkage; broken air cell.
4078	...do	0	0	0	0			0	0		Hatch spot size of nickel; good odor on opening; weak white and yolk; clean shell; marked shrinkage; broken air cell.
4079	...do	0	0	0	0			0	0		Hatch spot size of nickel; good odor on opening; weak white and yolk; clean shell; marked shrinkage; broken air cell.

	1911.										
4017	June 13	0	0	260	0	.....	.....	0	0	.....	
108-1	June 21	.....	.....	.....	.....	20	0	.....	.....	0	
108-2	...do.....	.....	.....	.....	.....	30	0	.....	.....	0	
108-3	...do.....	.....	.....	.....	.....	20	0	.....	.....	0	
108-4	...do.....	.....	.....	.....	.....	20	0	.....	.....	0	
108-5	...do.....	.....	.....	.....	.....	20	0	.....	.....	0	
108-6	...do.....	.....	.....	.....	.....	20	0	.....	.....	0	
4036	July 8	.....	.....	.....	.....	0	0	.....	.....	0	Fertile egg held at room temperature for 8 days; very weak yolk; marked shrinkage; fixed air cell.
4037	...do.....	.....	.....	.....	.....	0	0	.....	.....	0	Fertile egg held at room temperature for 8 days; yolk broken and blood ring stuck to shell; marked shrinkage; fixed air cell.
4219	July 11	.....	.....	.....	.....	.....	.....	.....	.....	0	Heavy blood ring; check.
4041	...do.....	0	0	0	0	.....	.....	0	0	.....	Yolk and also blood ring stuck to shell; moderate shrinkage; fixed air cell.
4042	...do.....	0	0	0	0	.....	.....	0	0	.....	Weak white and yolk; good odor on opening; marked shrinkage; movable air cell.
4043	...do.....	0	0	0	0	.....	.....	0	0	.....	Blood ring 1 cm in diameter; yolk stuck near air cell; good odor on opening; moderate shrinkage; fixed air cell.
4044	...do.....	0	0	20	0	.....	.....	0	0	.....	Yolk weak and in bottom of egg; watery white; marked shrinkage; movable air cell.
4046	...do.....	.....	.....	.....	.....	0	0	.....	.....	0	Yolk stuck in bottom of egg and broken; blood ring stuck to shell above yolk; good odor on opening; marked shrinkage; fixed air cell.
4047	...do.....	0	0	10	10	.....	.....	0	0	.....	Weak yolk with its blood ring stuck to shell; stale odor on opening; slight shrinkage; fixed air cell.
4088	Oct. 9	35	70	0	10	.....	.....	0	0	.....	Fecal dirty shell; good odor when egg was opened; weak white; some shrinkage; fixed air cell.

TABLE 6.—*Eggs changed by incubation*—Continued.

INDIVIDUAL EGGS WITH DEAD EMBRYOS (INCUBATION 48 HOURS OR MORE).

Sample No.	Date of examination.	White.		Yolk.		Whole egg.		Number of gas-producing bacteria per gram in lactose bile.			Description of sample.
		Total number of bacteria per gram on plain agar.									
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Whole egg.	
4058	1911. July 13	20	0	35	0	.....	.....	.....	.....	0	Contained an embryo about 8 days old; bad odor on opening; weak white and broken yolk; moderately clean shell; marked shrinkage; movable air cell.
4101	Nov. 1	.....	.....	.....	.....	0	130	.....	.....	0	Contained a broken-down blood ring; odor not bad on opening; white and yolk mixed; clean shell; marked shrinkage; movable air cell.
4102	...do.....	.....	.....	.....	.....	85	49,000	.....	.....	0	Contained much blood and an embryo about 5 days old; white and yolk mixed; clean shell; marked shrinkage; movable air cell.
4109	Nov. 7	.....	.....	.....	.....	18,000,000	28,000,000	.....	.....	0	Contained a broken-down blood ring; shell smeared and stained with feathers and feces; very stale odor on opening; white and yolk mixed; fixed air cell.
4111	...do.....	.....	.....	.....	.....	100,000	150,000	.....	.....	0	Contained a large chick; contents black under candle; shell not fresh looking; ethereal odor.
4112	...do.....	.....	.....	.....	.....	3,400	4,600	.....	.....	1,000	Contained an embryo about 2 days old; odor not bad on opening; white and yolk mixed; fairly clean shell; marked shrinkage; movable air cell.
4113	...do.....	.....	.....	.....	.....	120	150	.....	.....	0	Contained much blood and an embryo about 2 days old; stale odor; fairly clean shell; white and yolk mixed; marked shrinkage; movable air cell.
4115	...do.....	.....	.....	.....	.....	150	300	.....	.....	0	Contained an embryo about 5 days old; stale odor on opening; fairly clean shell; marked shrinkage; movable air cell.

Bacterially, these eggs show a wider range and a slightly higher average count than the two types previously discussed. All had the yolk and the white intact. In 11 of the examinations reported the white and yolk were studied separately. Two of the series were sterile and not one showed the presence of *B. coli*. The fact that the odor on opening these eggs was universally good is to be emphasized

The second series of Table 6 is composed of eggs which show before the candle the presence of blood in the germinal disk, and which are therefore equivalent to eggs at least 48 hours old at 103° F. In all of the eggs in this series the embryo was either alive or very recently dead, and the odor of the egg when opened was good. In all of them the presence of blood could be distinguished by means of the candle (see Pl. V). These eggs, in most instances, could be separated into white and yolk. The average count for such eggs showing blood rings, but without disintegration in the structure of the egg itself, is low, and some eggs are sterile.

The third series, where incubation had continued for more than the equivalent of 48 hours at 103° F. and where the embryo was dead and the structure of the egg damaged to a greater or less extent, shows a universally higher count than the other series and some individual counts which are strikingly high. *B. coli* were noted but once in this series. It will be observed that only one egg was separable into white and yolk. The odor was sometimes good and sometimes stale.

EGGS HAVING DIRTY SHELLS.

The egg with a dirty shell is one of the most objectionable factors of the egg industry. The contents may be fresh and the egg itself may be large, but the dirt on the shell consigns it at once to the seconds, and it brings a lowered price all through the market. Dirty-shell eggs do not store well and are therefore not available for holding when the surplus production is greatest and when the market can secure more good, clean eggs than it needs. Often they scarcely pay the expense of marketing. The breaker, therefore, removes the dirty shell and endeavors to put the contents into a form in which it can be marketed. The very objectionable filth on the exterior of the shell naturally inclines one to the opinion that the contents of the egg may also be contaminated. Such outer filth is not conclusive evidence that the contents are infected.

Table 7 gives the bacterial findings for 51 dirty-shell eggs of various grades of seconds and worse and 9 small samples, aggregating 1,164 eggs. Winter, spring, and summer eggs are included. The dirt on the shell consisted mostly of chicken feces and some dried mud or dried egg. Some of the shells were stained. These stains, which can not ordinarily be washed off, generally indicate that water as well as filth has come in contact with the egg shell.

TABLE 7.—*Eggs having dirty shells.*

INDIVIDUAL EGGS.

Sample No.	Date of examination.	White. Total number of bacteria per gram on plain agar. Incubated at 20° C.	White. Total number of bacteria per gram on plain agar. Incubated at 37° C.	Yolk. Total number of bacteria per gram on plain agar. Incubated at 20° C.	Yolk. Total number of bacteria per gram on plain agar. Incubated at 37° C.	Number of gas-producing bacteria per gram in lactose bile. White.	Number of gas-producing bacteria per gram in lactose bile. Yolk.	Description of sample.
	1911.							
3019–1	Mar. 14	60	20	.....	.....	.....	.....	Good quality.
3019–2	...do.....	25	70	.....	.....	.....	.....	Do.
3019–3	...do.....	75	5	.....	.....	.....	.....	Do.
3019–4	...do.....	25	0	.....	.....	.....	.....	Do.
3020–1	Mar. 20	0	0	.....	.....	.....	.....	Stale under candle; enlarged hatch spot.
3020–3	...do.....	0	0	.....	.....	.....	.....	Do.
3020–5	...do.....	0	0	.....	.....	.....	.....	Do.
3020–7	...do.....	0	0	.....	.....	.....	.....	Do.
3021–4	Mar. 21	0	0	.....	.....	.....	.....	Do.
3024–3	Apr. 4	0	0	.....	.....	.....	.....	Green stained shell, looks as though it had been washed; marked shrinkage.
3024–5	...do.....	0	5	.....	.....	.....	.....	Very dirty shell.
3024–13	...do.....	0	0	.....	.....	.....	.....	Badly stained egg with a tough vitelline membrane.
3025	Apr. 6	15	0	.....	.....	.....	.....	Very dirty shell; watery white; enlarged hatch spot; slight shrinkage.
3026–2	Apr. 7	0	0	.....	.....	.....	.....	A large hatch spot; slight shrinkage.
562	Aug. 21	70	70	.....	.....	.....	.....	Peculiar odor when egg was opened.
4067	Sept. 5	24,000,000	5,400,000	12,000,000	7,800,000	0	0	Very dirty shell; bad odor on opening; weak white; enlarged hatch spot; some shrinkage; fixed air cell.
4080	Sept. 21	190	20	0	0	0	0	Fecal dirty shell; good odor on opening; weak white; hatch spot size of dime; some shrinkage; fixed air cell.
4081	...do.....	0	0	0	0	0	0	Fecal dirty shell; slightly stale odor on opening; weak yolk; small hatch spot; some shrinkage; fixed air cell.
4082	...do.....	0	0	0	0	0	0	Good odor when egg was opened; weak white; some shrinkage; broken air cell.
4083	...do.....	3,100,000	2,200,000	1,600,000	1,400,000	0	0	Stained shell; looked as though it had been washed; stale odor when egg was opened; weak white and yolk; small hatch spot; marked shrinkage; very movable air cell.
4084	...do.....	0	0	35	125	0	0	Fecal dirty shell; stale odor; weak white and yolk; hatch spot size of dime; some shrinkage; slightly movable air cell.
4086	Oct. 9	10	550	10	.....	0	0	Fecal dirty shell; good odor when egg was opened; very much enlarged hatch spot; some shrinkage; movable air cell.
4096	Oct. 31	15	190	200	120	.....	.....	Shell looks as though it had been stained by damp straw; weak white; slightly enlarged hatch spot; some shrinkage; movable air cell.
4097	...do.....	0	0	0	0	0	0	Fecal dirty shell; weak white and yolk; enlarged hatch spot; some shrinkage; movable air cell.
4098	...do.....	50	70	0	0	0	0	Shell looks as though it may have been stained by dirty feet; floating yolk; slightly enlarged hatch spot; some shrinkage; fixed air cell.

4099	...do.....	5	15	15	35	0	0	Shell smeared with broken egg; weak white; sun-spotted yolk; hatch spot not enlarged; some shrinkage; movable air cell.
4100	...do.....	270	260	550	650	0	0	Shell looks as though stained by dirty feet; also smeared with broken egg; firm white; yolk at top of egg; some shrinkage; fixed air cell.
4116	Nov. 7	2,900	1,700	1,000	1,100	0	0	Very badly brown-stained shell; stale odor when egg was opened; some shrinkage; fixed air cell.
[1] 4124	Nov. 14	30	45	30	30	0	0	Somewhat stained and smeared with feces; good odor when egg was opened; weak white; hatch spot not enlarged; movable air cell.
4125	...do	30	15	25	35	0	0	Shell considerably smeared with feces; good odor when egg was opened; weak white; hatch spot not enlarged; movable air cell.
4126	...do.....	30	0	10	25	0	0	Shell smeared with ground dirt, but not stained; hatch spot not enlarged; good odor when egg was opened; marked shrinkage; fixed air cell.
4128	...do.....	72,000	4,000	.....	.....	0	0	A very badly brown-stained shell; good odor; hatch spot not enlarged; some shrinkage; fixed air cell.
4129	...do.....	1,600	25	65	45	0	0	Shell smeared with feces; odor not exactly good when egg was opened; firm white; hatch spot not enlarged; slight shrinkage; fixed air cell.
4130	...do.....	45	10	60	50	0	0	Shell smeared with dirt and feces; good odor on opening; some shrinkage; movable air cell.
4131	Nov. 23	5	10	25	0	0	0	Shell smeared with feces; weak yolk; hatch spot not enlarged; some shrinkage; movable air cell.
4133	...do.....	0	10	5	20	0	0	Shell greasy and smeared with feces; good odor when egg was opened; hatch spot not enlarged; marked shrinkage; movable air cell.
4134	...do.....	0	0	0	0	0	0	Shell stained and smeared in spots with feces; good odor when egg was opened; heavy roller; hatch spot size of dime; one-third shrinkage; movable air cell.
4135	...do.....	0	10	40	20	0	0	Shell smeared with feces; good odor when egg was opened; slightly enlarged hatch spot; some shrinkage; fixed air cell.
4136	...do.....	0	0	60	160	0	0	Shell smeared in spots with feces; weak white; weak yolk; hatch spot not enlarged; heavy roller; marked shrinkage; movable air cell.
4137	Nov. 13	30	4,600	290	75	0	0	Stained shell; firm white; hatch spot not enlarged; fixed air cell.
4138	Dec. 14	120	45	.....	220	0	0	Shell looked as though it had been wet; considerable shrinkage.
4139	...do.....	1,800	0	2,100	0	0	0	Shell smeared with feces; weak white; hatch spot not enlarged; some shrinkage; movable air cell.
4140	...do.....	0	0	130	0	0	0	Green-stained areas on shell; good odor when egg was opened; hatch spot not enlarged; little shrinkage; fixed air cell.
4142	...do.....	30	0	1,900	15	0	0	Fecal dirty shell; good odor when egg was opened; firm white; hatch spot not enlarged; quick roller; considerable shrinkage.
4143	...do.....	0	0	.....	0	0	0	Fecal dirty shell; barn odor when egg was opened; very weak white and yolk; considerable shrinkage; movable air cell.
4147	Dec. 15	45	100	180	75	0	0	Weak white; heavy quick roller; some shrinkage; movable air cell.
4148	...do.....	400	220	1,200	640	0	0	Shell smeared with broken egg and other dirt; hatch spot not enlarged; considerable shrinkage; movable air cell.
4149	...do.....	95	30	660	140	0	0	Fecal dirty shell; good odor when egg was broken; some skrinkage; movable air cell.
4150	Dec. 16	0	0	0	0	0	0	Fecal dirty shell; cracked on bottom; weak egg; heavy roller; enlarged hatch spot; some shrinkage; movable air cell.
4152	...do.....	0	0	15	5	0	0	Shell smeared with egg from case; good odor when egg was opened; hatch spot not enlarged; considerable shrinkage; movable air cell.
4154	...do.....	0	0	0	.....	0	0	Very weak egg; heavy roller; movable air cell.

[1] Samples 4124 to 4154 were selected Nov. 14, 1911. The eggs with odd numbers were washed and those with even numbers were not. All were kept in the laboratory at ordinary temperatures and different lots plated at varying intervals of time.

TABLE 7.—*Eggs having dirty shells*—Continued.

SMALL COMPOSITE SAMPLES.

Sample No.	Source.	Date of examination.	Whole egg. Total number of bacteria per gram on plain agar. Incubated at 20° C.	Whole egg. Total number of bacteria per gram on plain agar. Incubated at 37° C.	Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method. Wet basis.	Percentage of ammoniacal nitrogen, Folin method. Dry basis.	Moisture.	Size of sample.	Condition of sample.
		1911.						*Per cent.*	*Eggs.*	
265	.....	July 17	.....	90	0	0.0015	0.0082	.....	6	
278	.....	...do...	5	5	0	.0017	.0073	.....	6	
552	.....	Aug. 21	36,000	32,500	.....	.0018	.0070	.....	38	Good quality; very dirty.
553	.....	...do.....	0 in 100	0 in 100	.....	.0013	.0068	.....	38	Do.
554	.....	...do.....	0 in 100	0 in 100	.....	.0017	.0070	.....	38	Do.
555	.....	...do.....	0 in 100	0 in 100	.....	.0017	.0061	.....	38	Do.
		1912.								
4582	D 3	June 19	0 in 100	0 in 100	0	.0017	.0061	72.02	864	
4631	E 4	June 28	5,100,000	950	0	.0024	.0083	71.02	64	Very stale and dirty.
4951	E 5	Aug. 9	600,000	520,000	100	.0022	.0078	71.83	72	

The contents of these dirty-shell eggs listed in Table 7 are varied. Some show definite signs of incubation; some are aged eggs, as shown by shrinkage; some show weak whites, some settled yolks, etc. Bacterially this series, as might be expected, is very divergent in the number of organisms observed. Two eggs out of the 51 contain millions of organisms per gram in both white and yolk; 4 show a count running into the thousands; 9 have more than a hundred organisms per gram; and of the 36 remaining, 15, or 41.6 per cent, are sterile. It is of great interest to observe that although so many of these dirty shells were smeared with feces, which undoubtedly contained *B. coli*, this organism was not once obtained in the body of the egg, either in the white or in the yolk, and that it did not appear in those eggs which had been wet is a still more striking fact. This observation is in accordance with the work of Maurer.[1]

Sample 4083, with 3,100,000 organisms in the white, had a stale odor on opening and a stained shell, which looked as though it had been wet.

Sample 4128 had a very badly brown-stained shell, and though the odor of the egg was good on opening, 72,000 organisms per gram were found in the white. Sample 4137 showed 4,600 organisms per gram in the white, which may, perhaps, be accounted for by the stained shell. On the whole it is the stained shell which seems most likely to be the offender, an opinion which is strengthened by the observation that where there is a count of any magnitude it is not only most commonly in the eggs having stained shells, but the organisms are usually more abundant in the white of the egg than in the yolk, from which one might infer that the infection is from the exterior.

The nine samples, composed of more than one dirty-shell egg, vary in bacterial content just as do the individual eggs. The chemical analysis shows that the loosely bound nitrogen varies with the character of the egg, not with the quantity of dirt on the shells. Sample 4631, for instance, shows 0.0024 per cent of nitrogen and is described as very stale, but it was not any dirtier than Sample 553, wherein only 0.0013 per cent of nitrogen was obtained.

If one may draw any conclusion from the findings set forth in Table 7 it must be that the dirty shell, per se, is not a sufficient ground on which to condemn an egg, though the odor of the egg when opened should be carefully observed, especially if the shell shows stains or other evidences of having been wet.

[1] Bacteriological Studies on Eggs. Kansas State Agricultural College Bul. 180, 1911.

EGGS HAVING CRACKED SHELLS.

Mechanical injury to eggs, due to rough handling, is another great money loss to the egg industry and a food loss to the consumers. Many eggs are completely wrecked and are termed "mashed" eggs by the industry. In this case they are not only lost but they soil a number of eggs otherwise good. Where the shell is so broken that the contents are escaping the egg is termed a "leaker." In addition to leakers the industry has to contend with enormous numbers of "checks"—that is, eggs which have cracked shells but intact membranes.

Leakers are thrown out at every stage of handling, from the country merchant or egg peddler to the city retailer, and are generally a total loss. Checks are disposed of if possible and as near the gathering point as may be, because they are weakened mechanically and are free food for any bacterium or mold that may chance to fall into the crack. Hence they are sure, in commerce, to rot quickly. The cracked eggs coming to the breaker in the producing section are received by him much sooner after the damage is done than by the breaker in the consuming center, and for that reason they are usually in better bacterial condition. Table 8 gives the results of the examination of 56 of these cracked eggs, both blind and visible checks. Some of these eggs were fresh and above reproach except for the damaged shell; others had dirty as well as cracked shells, hatch spots, weak yolks, thin whites, etc.

TABLE 8.—*Eggs with cracked shells (membranes intact).*

INDIVIDUAL EGGS.

Sample No.	Date of examination.	White.		Yolk.		Whole egg.		Number of gas-producing bacteria per gram in lactose bile.			Description of sample.
		Total number of bacteria per gram on plain agar.									
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Whole egg.	
	1911.										
179–1	July 6					15	25			0	Firm yolk.
179–2	...do					0	230			0	Do.
208	July 8					370,000,000				10,000+	Cracks visible before candle only; bad odor.
209	...do					15	25			0	Many cracks on top of egg; visible before candle only.
210	...do					260	25			0	Cracks visible before candle only.
211	...do					65	35			0	Hole in top of egg; membrane intact.
218	July 11					25	0			0	Cracks visible before candle only; firm yolk.
219	...do					65	5			0	Heavy blood ring; cracks visible before candle only.
220	...do					55	20			0	Visible cracks all over shell; firm yolk.
221	...do					55	10			0	Visible cracks; hole in one end; weak yolk.
222	...do					40	10			0	Visible cracks.
223	...do					30	25			0	Open cracks; firm yolk.
224	...do					10	5			0	Small crack; cracks visible before candle only; weak yolk; small hatch spot.
225	...do					25	0			0	Visible cracks; cracks visible before candle only; enlarged hatch spot; firm yolk.
226	July 25					5	15			0	Cracks visible before candle only; weak yolk; small hatch spot.
331	...do					40	40			0	Good quality.
332	...do					20	30			0	Do.
333	...do					10	5			0	Do.
334	...do					0	10			0	Do.
336	...do					5	10			0	Do.
337	...do					5	20			0	Do.
338	...do					10	5			0	Do.
339	...do					20	20			0	Do.
341	...do					240	290			0	Crack with a hole; good quality.
342	...do					10	15			0	Do.
343	...do					5	5			0	Do.
344	...do					20	5			0	Do.
451	Aug. 15					150	125			0	Visible cracks; excelsior and paper filler was present on shell and also in egg, having entered same through crack.

TABLE 8.—*Eggs with cracked shells (membranes intact)*—Continued.

INDIVIDUAL EGGS—Continued.

Sample No.	Date of examination.	White.		Yolk.		Whole egg.		Number of gas-producing bacteria per gram in lactose bile.			Description of sample.
		Total number of bacteria per gram on plain agar.									
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Whole egg.	
	1911.										
3019-5	Mar. 13	32	0								Clean shell.
3019-6	...do....	43	0	200	75						Do.
3019-8	...do....	0	0								Very dirty shell; watery white.
4010	June 12			0	0					0	Visible cracks; firm white; no hatch spot; fixed air cell.
4051	July 19	0	0	0	0			0	0		Visible cracks; clean shell; yolk stuck near bottom; hatch spot; good odor; movable air cell; marked shrinkage.
4062	Sept. 5	370,000	370,000	2,200,000	Innumerable in 10,000.			100+	100+		Visible cracks; dirty shell; watery white; hatch spot; stale odor; marked shrinkage; movable air cell.
4064	...do....	150	75	100	100			0	0		Visible cracks; somewhat dirty shell; hatch spot; good odor; marked shrinkage; movable air cell.
4066	...do....		110	30	20			0	0		Visible cracks; clean shell; hatch spot size of a dime; good odor; fixed air cell.
4068	...do....	Innumerable in 1 to 100.	120,000	Innumerable in 1 to 100.	Innumerable in 1 to 100.			0	0		Visible cracks; dirty shell; hatch spot size of a dime; watery white; good odor; movable air cell.
4071	Sept. 8	15	70	50	75			0	0		Visible cracks; clean shell; hatch spot size of a quarter; weak white; marked shrinkage; movable air cell.
4072	...do....	40	25	25	35						Visible cracks; clean shell; hatch spot size of a 5-cent piece; good odor; some shrinkage; fixed air cell.
4073	...do....	170,000,000	33,000,000	49,000,000	9,100,000			100,000+	100,000+		Visible cracks; dirty shell; bad odor; hatch spot size of a nickel; weak white; some shrinkage; fixed air cell.
4074	...do....	20	35	530	370			0	0		Visible cracks; clean shell; hatch spot size of 1 square cm; watery white; good odor; some shrinkage; fixed air cell.
4090	Oct. 10	0	0	25	0			0	0		Visible cracks; clean shell; hatch spot size of a dollar; weak white; marked shrinkage; fixed air cell.
4091	...do....	0	2,700	20	950						Visible cracks; clean shell; stale odor; broken air cell.
4092	...do....	0	20		35			0	0		Visible cracks; clean shell; stale odor; weak white; no hatch spot; very marked shrinkage; movable air cell.

4093	...do.....	0	0	0	0	.....	.....	0	0	.....	Visible cracks; moderately clean shell; stale odor; weak white; hatch spot size of a dime; marked shrinkage; movable air cell.
4094	...do.....	0	10	10	0	.....	.....	0	0	.....	Visible cracks; clean shell; stale odor; marked shrinkage; movable air cell.
4095	...do.....	0	0	.....	7	.....	.....	0	0	.....	Visible cracks; dirty shell; stale odor; weak white; hatch spot size of dime; some shrinkage; movable air cell.
4107	Nov. 1	20	10	5	20	.....	.....	0	0	.....	Visible cracks on top of egg; shell dirty in places; good odor; watery white; no hatch spot; marked shrinkage; movable air cell.
4117	Nov. 10	25	15	45	75	.....	.....	0	0	.....	Visible cracks; fairly clean shell; good odor; small hatch spot; some shrinkage; fixed air cell.
4118	...do.....	25	25	75	90	.....	.....	0	0	.....	Visible cracks; clean shell; fresh odor; no hatch spot; marked shrinkage; fixed air cell.
4119	...do.....	0	15	20	55	.....	.....	0	0	.....	Visible cracks; clean shell; fresh odor; no hatch spot; fixed air cell.
4120	...do.....	20	30	15	50	.....	.....	0	0	.....	Visible cracks; shell dirty in spots; fresh odor; no hatch spot; some shrinkage; fixed air cell.
4121	...do.....	15	45	35	15	.....	.....	0	0	.....	Visible cracks; clean shell; fresh odor; a hatch spot; fixed air cell.
4122	...do.....	30	45	50	30	.....	.....	0	0	.....	Visible cracks; clean shell; fresh odor; weak white and yolk; marked shrinkage; movable air cell.
4123	...do.....	10	25	15	5	.....	.....	0	0	.....	Visible cracks; clean shell; fresh odor; weak yolk; fixed air cell.
4150	Dec. 16	0	0	0	0	.....	.....	0	0	.....	Visible cracks on bottom of egg; fecal dirt on shell; no hatch spot; some shrinkage; movable air cell.

TABLE 8.—*Eggs with cracked shells (membranes intact)*—Continued.

SMALL COMPOSITE SAMPLES.

Sample No.	Source.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Moisture.	Size of sample.	Description.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1911.						*Per cent.*	*Eggs.*	
620	.....	Aug. 30	450	150	0 in 100	0.0014	.....	.....	36	Current receipts.
621	.....	...do.....	150	300	0 in 100	.0014	.....	.....	36	Do.
622	.....	...do.....	650	50	0 in 100	.0015	.....	.....	36	Do.
623	.....	...do.....	0	200	0 in 100	.0015	.....	.....	36	Do.
		1912.								
4573	D3	June 19	200	350	0	.0018	0.0065	72.09	72	Badly shrunken.
4632	E4	June 28	97,000	15,500	10,000	.0019	.0067	71.58	72	Shrunken.
41043	D6	Aug. 23	5,300,000	2,500,000	10	.0024	.0083	71.24	72	14 hatch spots; 29 broken yolks.
41044	D6	...do.....	3,800,000	2,200,000	0	.0020	.0072	72.38	72	36 hatch spots.

Like the eggs with dirty shells, there is a wide variation in the number of bacteria, though only 5 out of the 56 individual eggs listed are sterile in a dilution of 1 to 10, and when the count is beyond a few hundred organisms per gram it is generally very high—that is, in the hundreds of thousands or millions. Four eggs have a bacterial content which is much higher than that observed in the other 52 eggs, ranging from 2,700 to 370,000,000 per gram. In three cases out of the four an objectionable odor was noticed when the egg was opened, and three of these eggs had dirty as well as cracked shells. *B. coli*, though sought in all but five of the samples, were found in but three instances and then in eggs which showed a high count. Here, again, the whites of the heavily infected eggs show a much higher count than the corresponding yolks. This is quite in line with the origin of the infection.

The samples from small lots of eggs with cracked shells bear out the findings from the individual eggs. Where the eggs with cracked shells are of good quality, both chemical and bacterial analyses indicate that fact. Where deterioration has begun, the cracking of the shell does not materially alter its course, but it hastens decay. Of course, the protection which the shell affords is lessened by cracking, and bacterial invasion is only a question of time and environment.

EGGS HAVING THE YOLK SEEPING INTO THE WHITE.

During warm weather, when the deterioration of eggs proceeds with great rapidity and in the most diversified fashion, many eggs are received at the concentrating centers, especially those reached by railroad or where the wagon haul is over rough roads, which show on candling filaments of yolk that have apparently found their way through apertures in the vitelline membrane for longer or shorter distances into the white.

Sometimes these filaments are very few and distinct, half an inch or more in length; in that case the egg white is usually normal in color, even between the filaments. Sometimes the seepage of the yolk into the white might be better described as diffuse, in which case very numerous and tiny filaments make a yellow zone around the yolk membrane, the outer portions of white remaining clear and the usual color. As the process of mixing progresses the white becomes more and more yellow and the vitelline membrane less and less resistant, until finally the latter ruptures and a complete mixing of yolk and white follows.

Even the most careful cracking of the shell at its equator is at times sufficient to rupture the yolk membrane extensively, thus permitting the yolk to escape entirely. At other times a fairly clean separation of white and yolk can be made. Generally such eggs exhibit, in addition to the filamentous yolk, distinct signs of age, such as shrinkage, and of rough handling, as shown by the movable air cell. Ordinarily the odor is good or somewhat stale, the sort of odor

that the housewife terms "eggy" or "strong." If the odor is not bad and if the mixing of the yolk and white is slight, the housewife uses these eggs for general cookery, though when the whites are to be whipped separately to lightness they are not satisfactory. The egg shipper does not attempt to send such eggs on long or hard journeys, because this mixing is accelerated by jarring; nor does he attempt to store them, because white and yolk continue to mix more and more rapidly. These eggs are therefore used very largely by the breakers. They should be examined very carefully for odor and appearance when broken, as they may be incipient forms of the "sour egg" (see p. 61). Table 9 illustrates the condition of this series.

TABLE 9.—*Eggs with the yolk seeping into the white.*

INDIVIDUAL EGGS.

Sample No.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Description.
		20° C.	37° C.		
	1910.				
3006–4	Dec. 12	77,000	83,000	.....	
3006–5	...do....	39	100	.....	
3010–2	...do....	25	15	.....	
	1911.				
4003	June 12	10	10	0	
111–2	June 21	5	15	0	Marked shrinkage—fixed air cell.
111–3	...do....	60	0	0	
111–4	...do....	5	0	0	
111–5	...do....	30	0	0	
111–6	...do....	10	0	0	
111–7	...do....	0	0	0	
122	June 24	10	0	0	Early stage.
124	...do....	5	5	0	Do.
125	...do....	5	0	0	"Strong" odor.
	1912.				
136	June 27	50	30	0	Early stage.
	1911.				
217	July 11	10	10	0	
4103	Nov. 1	5	90	0	Clean shell; stale odor; marked shrinkage; movable air cell.
4108	Nov. 7	2,000,000	1,700,000	0	Shell clean, but not fresh looking; stale odor; marked shrinkage; movable air cell.

SMALL SAMPLES.

Sample No.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Ether extract.	Size of sample.	
		20° C.	37° C.			Wet basis.	Dry basis.			Bacteriological.	Chemical.
	1911.									*Eggs.*	*Eggs.*
115	June 23	3	3	0	0	.....	.....	72.35	10.96	12	24
170	July 3	100	5	0	0	0.0033	0.0111	70.31	12.45	12	24
171	...do....	90	0	0	0	.0033	.0112	70.66	11.97	1	4
172	...do....	100	.....	.....	.....	.0032	.0114	71.84	10.86	1	4
173	...do....	100	35	0	0	.0029	.0103	71.78	10.55	1	4
174	...do....	180	5	0	0	.0038	.0141	73.12	10.01	1	4

Two of the eggs show decidedly high counts. The first, Sample 3006–4, was a winter egg and had probably been held by the farmer or merchant for a long time. The second high count, Sample 4108, was a July egg, and its bacterial condition might be explained by the fact that the shell showed signs of much handling, and the egg had acquired a stale odor. The other samples of the series show low counts; there was an absence of *B. coli* throughout, even in the case of the two high-count eggs.

Six small lots of eggs, where deterioration had gone further than in the type just described, were also examined for bacteria and loosely bound nitrogen. The number of organisms was negligible; the amount of loosely combined nitrogen was higher than had been previously noted. All of these eggs would have been discarded by a careful grader because of the yellow color of the white. Just where to draw the line, however, is not a simple matter. Practical experience would indicate that when the white of the egg was normal in color and when the filaments of yolk were entirely distinct from the white, or when, if the seepage was by the diffuse rather than the localized method, the outer zone of egg white was normal, the bacterial content was low and the loosely bound nitrogen did not rise above 0.0038 per cent.

WHITE ROTS.

If the egg, where white and yolk are just beginning to mix by either method of seepage, be held under commercial conditions, it becomes what is known to egg candlers as a "white rot," or to some as a "sour rot," but the latter is a misleading term and should be discarded. The inexpert or careless candler fails to notice these white rots; hence they are too often found in the breaking room; when opened yolk and white are seen to be completely, or almost completely, mixed. Very frequently the mixture is much thinner than the mixed yolk and white of a fresh egg and may or may not have an offensive odor. Its appearance is never appetizing. Sometimes scraps of membrane are seen, suggesting a disintegrated embryo; again, the contents are thin, homogeneous, and pale yellow (see Pl. VII). The series of eggs given in Table 10 is typical of eggs having these characteristics.

TABLE 10.—*White rots (individual eggs).*

Sample No.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Description of sample.
		20° C.	37° C.		
3006–2	Dec. 12, 1910	110,000,000	15,000,000	.....	Pale yellow contents.
3006–3	.....do.....	.....	80,000,000	.....	
3012–4	Jan. 14, 1911	0	295	.....	
275	July 3, 1911	5,500,000	3,300,000	0	
495	Aug. 10, 1911	(1)	(1)	10,000+	
496	.....do.....	0	0	0	
497	.....do.....	(1)	(1)	10,000+	
498	.....do.....	120,000	120,000	0	
499	.....do.....	0	0	0	
500	.....do.....	(1)	(1)	10,000+	
4070	Sept. 5, 1911	180,000,000	270,000,000	100+	Clean shell; marked shrinkage; movable air cell.
4110	Nov. 1, 1911	160	180	0	Shell slightly dirty but fresh looking; stale odor; marked shrinkage; movable air cell.

[1] Innumerable; dilution, 1: 10,000.

The bacterial content in 8 out of the 12 is very high. Two of the eggs were sterile and two of them showed a low count. *B. coli* were looked for 9 times out of the 12 and found 4 times.

The high bacterial content of these white rots is quite in accord with their appearance. Why there should occasionally be a white rot with a low count, as in Samples 3012–4, 498, and 4110, or even a sterile white rot,[1] as in Samples 496 and 499, remains to be explained. Since these white rots seem to be the logical sequence of the mixed egg, they might easily parallel the latter in their bacterial content.

EGGS HAVING YOLK ADHERENT TO SHELL (SPOT ROTS).

The "spot rots" of commerce are eggs in which the yolk has become adherent to one or both of the shell membranes and, perhaps, to the shell itself by means of the membranes. When held before the candle, therefore, the yolk is seen as a distorted, deeply colored mass pressed against some part of the shell (see Pl. IV). As the egg ages in temperatures which are lower than those causing incubation phenomena, the yolk of either the fertile or the infertile egg settles. If the egg is not moved the yolk finally adheres to the membrane against which it rests and it becomes a "spot rot" or, as termed in this report, an egg with the yolk adherent to the shell. If the egg is infertile and ages at such temperatures as prevail in summer time, the yolk frequently rises, presses against the air cell, and finally sticks there. Forty-two such eggs are listed in Table 11. When held before the candle some show no marked characteristics except the adherent yolk. Others show distinct evidences of incubation, general deterioration, cracked shells, etc.

[1] In a dilution of 1 to 10.

TABLE 11.—*Individual eggs with yolk stuck to shell.*

Sample No.	Date of examination.	White.		Yolk.		Number of gas-producing bacteria per gram in lactose bile.		Description of sample.
		Total number of bacteria per gram on plain agar.						
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	
	1910.							
3008–4	Dec. 23	[1] 100	56	.....	.....	.....	.....	White and yolk stuck to side of shell.
	1911.							
3012–1	Jan. 14	240,000,000	36,000,000	7,000,000	4,300,000	.....	.....	Yolk stuck to shell under dirt spot.
3014–5	Jan. 19	.....	.....	[2] 1,800	[2] 280	.....	.....	Dirty shell; yolk stuck to shell under dirt spot.
3014–6	...do.....	.....	.....	[3] 280	[3] 350	.....	.....	Dirty shell.
3017–1	Feb. 3	[1] 37,000,000	.....	.....	.....	.....	.....	Sour odor on opening.
3017–2	...do.....	.....	.....	.....	65,000,000	.....	.....	Dirty shell; thin white; yolk stuck near air cell.
3018–1	Feb. 6	0	.....	.....	.....	.....	.....	Slightly dirty shell; yellowish white.
3018–3	...do.....	0	.....	.....	.....	.....	.....	Dirty shell.
3018–4	...do.....	0	.....	.....	.....	.....	.....	Dirty shell; yellowish white.
3021–1	Mar. 21	0	0	.....	.....	.....	.....	
3021–2	...do.....	0	0	.....	.....	.....	.....	
3022–1	Mar. 24	9	9	.....	.....	.....	.....	
3025–7	Apr. 6	0	0	.....	.....	.....	.....	Thick shell; decided hatch spot.
4001	June 2	[1] 50	[1] 0	.....	.....	[1] 0	.....	Yolk stuck near air cell.
4002	June 12	20	30	.....	.....	.....	.....	Yolk stuck to shell and broken; marked shrinkage.
4007	...do.....	0	0	0	10	0	0	Yolk stuck but not broken; badly shrunken.
4009	...do.....	20	10	20	30	0	0	Badly shrunken; firm air cell.
4019	June 28	0	0	0	0	0	0	Enlarged hatch spot; marked shrinkage; movable air cell.
4020	...do.....	0	0	0	[4] 0	0	.....	Enlarged hatch spot; watery white; marked shrinkage; movable air cell.
4021	...do.....	([5])	([5])	57,000,000	67,000,000	0	0	Yolk stuck to bottom of shell; shook loose; watery white; marked shrinkage; movable air cell.
4022	...do.....	0	0	0	0	0	0	Yolk stuck near bottom of shell; watery white; marked shrinkage; movable air cell.
4023	...do.....	20	20	25	20	0	0	Yolk stuck near air cell; hatch spot enlarged; watery white; marked shrinkage; movable air cell.
4024	...do.....	.....	0	50	0	0	0	Do.
4025	June 30	10	10	10	10	0	0	Yolk stuck near air cell; enlarged hatch spot; watery white; marked shrinkage; movable air cell.
4028	July 5	240	20	40	10	10	0	Dirty shell; yolk stuck near air cell; watery white; marked shrinkage; movable air cell.
4030	...do.....	150,000	97,000	140,000	140,000	10	10+	Yolk stuck near air cell; no hatch spot; watery white; marked shrinkage; movable air cell; stale odor on opening.

[1] White and yolk mixed.
[2] 3014–5, 38,500 molds, at 20° C.; 350 molds, at 37° C.
[3] 3014–6, 12,000 molds in yolk at 20° C.
[4] 4020, 170,000 molds in yoke.
[5] Innumerable at 100,000.

TABLE 11.—*Individual eggs with yolk stuck to shell*—Continued.

Sample No.	Date of examination.	White.		Yolk.		Number of gas-producing bacteria per gram in lactose bile.		Description of sample.
		Total number of bacteria per gram on plain agar.						
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	
	1911.							
4035	July 5	270,000,000	160,000,000	1,100,000	710,000	.....	10	Yolk stuck to side of shell; enlarged hatch spot; watery white; marked shrinkage; movable air cell.
4048	July 11	10	0	70	35	0	0	Yolk stuck near bottom of shell; bad odor on opening; watery pink white; marked shrinkage; movable air cell.
4049	...do.....	260,000,000	320,000,000	14,000,000	140,000,000	0	0	Cracked, dirty shell; odor not good on opening; marked shrinkage; movable air cell.
4050	...do.....	0	0	20	0	0	0	Yolk stuck near air cell; watery white; no hatch spot; movable air cell; marked shrinkage; good odor on opening.
4051	July 12	0	0	20	0	0	0	Cracked, clean shell; yolk stuck near bottom of shell; good odor on opening; marked shrinkage.
4052	...do.....	0	0	0	0	0	0	Clean shell; yolk stuck near air cell; large hatch spot; good odor on opening; watery white; marked shrinkage; movable air cell.
4053	...do.....	0	0	.....	.....	0	0	Dirty shell; yolk stuck two-thirds down shell; good odor on opening; no hatch spot, marked shrinkage; movable air cell.
4055	...do.....	10	10	.....	.....	10	.....	Clean shell; yolk stuck near air cell; watery white; marked shrinkage; movable air cell.
4056	July 13	20	0	80	40	.....	10	Clean shell; yolk stuck near bottom; shook loose; moderate shrinkage; fixed air cell.
4141	Dec. 14	2,300,000	2,700,000	1,100,000	970,000	0	0	Dirty green-stained shell; yolk stuck but shook loose; weak white; very movable air cell.
4153	Dec. 16	0	0	25	340	0	0	Fecal dirty shell; yolk stuck near air cell but shook loose; no hatch spot; movable air cell; fairly good odor on opening.
4155	Nov. 28	0	0	0	0	0	0	Kept in cold storage for about six months; clean shell; yolk stuck two-thirds from side of shell; movable air cell.
4156	...do.....	0	0	0	0	0	0	In cold storage about six months; shell dirty in spots; yolk stuck two-thirds down side of shell; odor not fresh; hatch spot size of quarter; fixed air cell.
4157	...do.....	(1)	29,000,000	94,000	71,000	0	0	In cold storage about six months; greasy, stained shell; weak cloudy white; yolk stuck two-thirds down side of shell; bad odor; movable air cell.
4158	...do.....	0	0	35	0	0	0	In storage about six months; clean shell; large hatch spot; weak white; bad odor; marked shrinkage; movable air cell.
4159	...do.....	0	70	0	10	0	0	In storage about six months; clean shell; yolk stuck two-thirds toward bottom of shell; odor not fresh; one-third shrunken.

[1] Innumerable at 10,000.

Nine of the 42 eggs—or 21 per cent—show very high counts, the maximum being 320,000,000 bacteria per gram in the white of Sample 4049. The lowest count in these infected eggs is 150,000 per gram in the white and 94,000 in the yolk. Then there is a sudden drop to 1,800 per gram in Sample 3014–5, and the 18 remaining samples—or 43 per cent—which show bacteria present have so few that they may be neglected for practical purposes. Fourteen samples—or 33 per cent—were sterile in both yolk and white. The organisms in Sample 3012–1 were probably from the dirt spot on the shell against which the yolk had lain. Sample 3017–1 had a sour odor which indicates bacterial contamination in quantity; 3017–2 had a dirty shell; 4030, 4049, and 4157 had objectionable odors on opening; 4141 had a stained shell. Samples 3017–2 and 4021 had no distinctive feature except the adherent yolk.

MOLDY EGGS.

Damp cellars, wet nests, stolen nests, etc., are responsible for the condition of eggs which show, on candling, dense black areas of varying sizes inside the shell. When the eggs are opened these areas are found to be infected with a mold, usually a common green mold, of the Penicillium family (see Pl. VI). Such eggs almost invariably have a moldy odor. If the mold spot is small it may not affect the integrity of the egg structure; on the other hand, it may grow to such dimensions that no distinction between yolk and white can be seen.

The products of the growth of the mold may gelatinize the white or liquefy it and may coagulate the yolk into a cheesy mass or render it watery. It is, however, but seldom that a mold in pure culture is found inside an egg; generally bacteria are also present, and sometimes in large numbers. Both the white and the yolk of moldy eggs are apt to be discolored, usually becoming brownish. This color is not always confined to the area of visible mold, but may be diffused throughout, as shown by cultures made from white and yolk remote from the visible infection. These and other characteristics are noted in Table 12, where the results of the examination of 45 individual eggs showing mold visible to the eye are recorded.

TABLE 12.—*Individual moldy eggs.*

Sample No.	Date of examination.	White.				Yolk.				Whole egg.				Number of gas-producing bacteria per gram in lactose bile.			Description of sample
		Total number of bacteria and molds per gram on plain agar.															
		Bacteria.		Molds.		Bacteria.		Molds.		Bacteria.		Molds.					
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Mixed.	
	1910.																
3007-2	Dec. 21	28,000	34,000	0	0	20,000,000	7	0	0	350	9	30	0	.....	.....	.....	Green mold in air cell.
3007-4	...do....	.....	.....	.....	.....	.....	.....	.....	.....	0	22	0	0	.....	.....	.....	White blackened in place against shell.
3011-1	Dec. 29	47	23	0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
3011-3	...do....	15	8	54	0	.....	.....	.....	.....	0	15	6,600	0	.....	.....	.....	One black mold spot under candle.
3011-5	...do....	12,000,000	5,500,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
3011-6	...do....	0	0	570	400	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	
	1911.																
3012-6	Jan. 14	.....	.....	.....	.....	.....	.....	.....	.....	0	0	5,400	130,000	.....	.....	.....	Considerable mold in air cell; white coagulated against shell in places.
3013-1	Jan. 16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	57,000	73,000	.....	.....	.....	Considerable mold in air cell.
3013-2	...do....	.....	.....	.....	.....	.....	.....	.....	.....	360	160	5,300	5,100	.....	.....	.....	Considerable mold in air cell; dirty shell.
3013-4	...do....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Contents of egg moldy where contents of egg were stuck to shell.
3014-1	Jan. 19	.....	.....	.....	.....	.....	.....	.....	.....	850	630	0	0	.....	.....	.....	Badly shrunken egg with mold in air cell; marked shrinkage.
3014-2	...do....	540	540	0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	White in bottom of egg coagulated by mold; white near air cell plated.
3014-3	...do....	.....	.....	.....	.....	.....	.....	.....	.....	2,500,000	5,000,000	0	0	.....	.....	.....	Small black mold spot.
3015-1	Jan. 24	.....	.....	.....	.....	0	9	1,500	0	.....	.....	.....	.....	.....	.....	.....	Green mold in air cell; yolk underneath mold spot plated; musty odor.
3015-2	...do....	.....	.....	.....	.....	24	12	36	0	.....	.....	.....	.....	.....	.....	.....	One mold spot inside of shell; white underneath mold spot coagulated.
3016-4	Jan. 30	6	13	0	0	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Mold in air cell on one side of egg; white from opposite side plated; considerable shrinkage.
3016-6	...do....	.....	.....	.....	.....	.....	.....	.....	.....	320	430	150	32,000	.....	.....	.....	White, wooly mold in air cell; yolk beneath light in color and friable.

3017-3	Feb. 3						Few.		17,000								Mold in air cell and inside of shell; the latter mottled with gray spots; yolk underneath air cell plated.
3017-4	...do		0		70												Considerable mold present; white dark in color.
3017-5	...do		0		1,900												Large mold spot on side of egg; white dark in color and somewhat thickened.
3018-7	Feb. 6									[1] 1,000,000							Yolk stuck against shell by mold; dirty shell; white and yolk underneath mold spot plated.
4011	June 12	0	0	64,000	73,000									0			Mold covers one-sixth area of shell; yolk stuck to mold; badly shrunken; movable air cell.
4026	July 5	67,000,000	18,000,000	0	0	45,000,000	180,000,000	0	0					0	0		Dirty-shelled egg; yolk stuck near air cell, some odor; slight shrinkage; fixed air cell.
4027	...do	0	0	1,500	10	11,000	0	43,000	0					0	0		Yolk moldy and stuck near bottom of egg; stale odor; weak white; dirty shell; marked shrinkage; movable air cell.
4029	...do	100,000,000	51,000,000	0	0	220,000,000	190,000,000	0	0					100+			Mold in air cell; dirty-shelled egg; yolk stuck near air cell; putrid odor; slight shrinkage; fixed air cell.
4031	...do					490,000		16,000									Yolk stuck one-half way up shell and moldy; slightly sour stale odor; slight shrinkage; fixed air cell.
4032	...do	17,000,000	4,800,000	0	0	94,000,000	140,000,000	0	0					10	100+		Mold in air cell; yolk stuck to shell; stale odor; slight shrinkage; fixed air cell.
4033	...do					89,000,000		0	0								Mold in air cell; watery white; yolk stuck but not moldy; marked shrinkage; movable air cell.
4054	July 12									0	0	10	0			0	Mold spot on bottom of yolk; yolk stuck near air cell; moderately clean shell; slightly movable air cell.
4069	Sept. 5			70	130,000	Few.	Few.	0	140,000					0	0		Moldy along crack; clean shell.
4104	Nov. 1									10,000	6,700	0	0			0	One mold spot on inside of shell; white and yolk mixed; clean shelled; very marked shrinkage; movable air cell.
4105	...do	140,000,000	45,000,000	0	0	2,300,000	1,500,000							0	0		Mold spots on inside of shell where yolk is stuck; a very dirty-shelled egg; broken air cell.
4106	...do	0	0	380	380	0	0	42,000	66,000					0	0		Mold spots on inside of shell where yolk is stuck; clean shelled; marked shrinkage; weak white; movable air cell.

[1] Total bacteria and molds.

TABLE 12.—*Individual moldy eggs*—Continued.

Sample No.	Date of examination.	White.				Yolk.				Whole egg.				Number of gas-producing bacteria per gram in lactose bile.			Description of sample.
		Total number of bacteria and molds per gram on plain agar.															
		Bacteria.		Molds.		Bacteria.		Molds.		Bacteria.		Molds.					
		Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	Incubated at 20° C.	Incubated at 37° C.	White.	Yolk.	Mixed.	
	1911.																
390–1	Nov. 15									0	310	38,000	0			0	Mold covers yolk and is present in spots on inside of shell; yolk stuck to shell; watery white.
390–2	...do...									0	60	12,500	0			0	Mold covers yolk and inside of shell; yolk stuck in bottom of shell; watery white.
390–3	...do...									0	25	21,000	0			0	Mold covering one-half area of yolk and present in spots on shell.
390–4	...do...									0	5	0	0			0	Mold covers yolk and inside of shell; white and yolk mixed.
390–5	...do...									0	5	88,000	0			0	Mold present in small spots on air cell.
390–6	...do...									0	10	6,000	0			0	Mold present in spots on yolk only; yolk stuck in bottom of shell.
390–1/2	Dec. 14											[2] 900	11,000,000			0	Yolk stuck in bottom of shell, broken and covered in spots with mold; watery white; movable air cell.
390–2/2	...do...									0	15	72,000	0			0	Mold spots all over inside of shell and a large spot on yolk which was stuck to shell near the middle of the egg; watery, gassy white; marked shrinkage.
390–3/2	...do...									0	5	43,500	0			0	Mold covering nearly all of entire yolk and present in spots on adjoining white and also in air cell; yolk stuck on one side of shell near air cell; one-fifth shrunken.
390–4/2	...do...									0	130	26,000	0			0	Mold covering nearly all of yolk and present in spots on white; yolk stuck in bottom of shell; watery white; movable air cell.

390–5/2	do										0	0	280,000	0			0	Mold nearly covering entire yolk and present in isolated spots all over inside of shell; yolk stuck in bottom of shell and broken; cracked shell.
390–6/2	do										0	0	110,000	0				Mold covering entire yolk and present in isolated islands in neighboring white; yolk stuck to side of shell near air cell.

[1] Fresh eggs placed in storage in April, 1911; during the period of storage there was a leak in the ice box in the room above. When the eggs were taken out in November many were found to be moldy.

[2] Total bacteria and molds.

It is interesting to observe that *B. coli* were found in but 2 of the 45 eggs; that in those cases it was present in small numbers only and then with large numbers of other bacteria. In fact, the mold in Samples 4029 and 4032, respectively, was in the air cell and apparently had not penetrated the egg membrane, though undoubtedly it would have done so in time. It is also of interest to note that the odor of Sample 4029 was putrid and that of 4032 stale; both had yolks stuck to the shell.

Molds, as indicated by the descriptions given in Table 12, may appear in clean and dirty shell eggs. If the shell is dirty, the first visible spot of mold is very often beneath the spot of dirt. Since the mold infections seem to be due almost entirely to shell penetration after laying, one would expect to find the egg—both yolk and white—adhering to the membrane. Such is usually the case if the growth is extensive.

So varied are the visible results upon the egg of the growth of mold inside the shell that much space might be consumed describing individual eggs. The salient points for our purpose, however, are the facts that the eggs which show mold before the candle give a growth of mold when the egg substance is transferred to suitable culture media, and a study of the substance of such eggs shows that the mold is not confined to the area where it is visible, but is commonly diffused throughout both white and yolk. A moldy egg is also likely to show a large number of bacteria present.

BLACK ROTS.

Black rots need but short comment here. They are recorded for comparative purposes only. Table 13 gives the bacterial findings in 10 of them. The odor and appearance, both before the candle and after opening, would exclude their use for any food purpose or even for leather tanning. They could be used for fertilizer.

TABLE 13.—*Black rots—individual eggs.*

Sample No.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Description.
		20° C.	37° C.		
	1910.				
3007–6	Dec. 21	180,000,000	140,000,000	.....	Thin, watery contents, with bad odor.
3009–5	Dec. 27	49,000,000	7,500,000	.....	Watery contents, with strong odor.
3009–6	...do.....	4,200,000,000	6,300,000,000	.....	Watery, olive-green, gassy contents, with bad odor.
3010–1	Dec. 28	120,000,000	33,000,000	.....	Green contents, with strong odor.
	1911.				
3012–3	Jan. 14	.....	790,000,000	.....	Brownish, gassy contents, with bad odor.
4045	July 11	350,000,000	340,000,000	1,000,000+	Black under candle; egg had a bad odor before being opened, and a still worse one afterwards; some shrinkage; fixed air cell.

TABLE 13.—*Black rots—individual eggs*—Continued.

Sample No.	Date of examination.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Description.
		20° C.	37° C.		
4059	1911. July 13	67,000,000	.....	1,000,000	Black under candle; contents were very gassy and had a frightful odor; clean shell; marked shrinkage; movable air cell.
4060	...do.....	11,000,000	5,400,000	1,000,000+	Black under candle; bad odor on opening; clean shell; marked shrinkage; movable air cell.
4087	Oct. 9	660,000,000	180,000,000	0	Black under candle; shell dirty and stained in one spot with a damp feather, underneath which was a mold spot; balance of the egg was a black rot.
4114	Nov. 7	160,000,000	280,000,000	100	Black under candle; strong odor of hydrogen sulphid; inside of shell and shell membrane black; shell not fresh looking; one-third shrinkage.

The maximum bacterial count was 6,300,000,000 per gram; the minimum 5,400,000. *B. coli* were looked for five times and found four times—in very large numbers except in one sample.

COMPOSITE SAMPLES OF EGGS OPENED COMMERCIALLY IN THE PACKING HOUSE.

The study of eggs opened aseptically in the laboratory is logically followed by a study of eggs broken commercially in the packing house. For this investigation a large number of samples were taken of the various types of eggs encountered throughout the egg-breaking season of 1912. It was hoped that the laboratory results, together with the characteristic appearance and odor of the different classes of eggs, would give a practical working basis for the grading of eggs used in the preparation of frozen and desiccated eggs.

The commercial conditions under which the eggs were broken are described in the discussion of D, E, and F houses for 1912, in a forthcoming Department of Agriculture bulletin. The method of opening was in brief as follows: The eggs were broken on a sterilized knife edge, the two sections of the shell pulled apart with the thumb and first and second fingers of each hand, and the contents of the egg allowed to drop into a sterile cup. After every infected egg which could be detected by the senses, the operator replaced the knife and cup with sterile equipment and washed and dried her hands. The fingers were kept dry by means of tissue paper or small towels, which were used but once before laundering. By this method the contamination of the liquid egg during the process of breaking was reduced to a minimum.

If the sample consisted of less than 9 eggs, the liquids were poured directly from the cups to a sterile 16-ounce salt-mouthed bottle,

mixed by shaking, and a small portion of the mixture was transferred to a sterile 4-ounce bottle containing pieces of sterile glass; the large sample was for chemical analyses, the smaller one for bacteriological examination. If the specimen represented 9 or more eggs, the eggs were collected in a suitable container and mixed, a bacteriological and a chemical sample being taken. The samples were frozen in a sharp freezer 12 hours or less, packed in chilled, cork-insulated boxes especially constructed for the purpose, and shipped by express to the laboratory, where they arrived hard frozen. About 3 hours were required for transportation from E house and about 12 hours from D and F houses.

The samples were taken on the successive weekly visits made at D, E, and F houses during the season of 1912. A section in each of the tables containing the laboratory results of this research indicates the time and place of sampling. For example, F–5, in Table 14, signifies that the sample was taken on the fifth visit to F house. The number of eggs represented in each sample varied from 4 to 360.

JULY AND AUGUST FIRSTS.

Since strictly fresh eggs are not used in the United States for the preparation of frozen and desiccated eggs, no studies were made of this grade opened under commercial conditions. During the latter part of July and August, however, when receipts are not only light but also low in quality and cheap, eggs commercially graded as firsts are sometimes used to piece out the regular supply of breaking stock. The firsts of the summer and autumn months differ before the candle from the firsts of the spring months in that the former are much more shrunken, the yolks more opaque, and the whites are less firm. Firsts, also commercially termed "storage-packed No. 1 eggs," constituted a large percentage of the breaking stock used in F house during the season of 1912. They were graded from the daily receipts and held in chilled rooms until needed to fill out the regular quota of eggs for the breaking room.

On the last two visits to F house samples were taken of the liquid egg broken from five lots of firsts, each representing 15 dozen eggs (see Table 14). Care was taken during the process of breaking to eliminate all eggs which might have a deleterious effect on the liquid product. For example, from one sample an egg with a green white was discarded and from a second an egg with a broken yolk which at one time had been adherent to the shell. Some of the firsts had cloudy whites, but such eggs were not discarded in the preparation of these samples because laboratory studies proved that they were not infected.

The laboratory data given in Table 14 show that three of five samples contained less than 1,000 bacteria per gram at 20° C. and the other two 25,000 and 92,000, respectively. In three samples *B. coli* were not found and in the remaining two they were present in small numbers. Since the bacteriological findings given in Table 4 indicate that this grade of eggs, when opened aseptically, is practically sterile and contains no *B. coli*, it might be concluded that the organisms found in the samples opened in the packing house were referable, for the most part, to outside contamination and not to the eggs themselves. On the basis of this assumption these results will be taken as a standard of comparison in the succeeding discussion of the bacterial contents of other types of eggs.

The moisture content of four of the five samples of firsts was lower than the amount found in fresh eggs, which result would be expected from the difference in the amount of shrinkage in the two types of eggs. The average percentage of ammoniacal nitrogen, which was taken as the index of protein decomposition, was 0.0020 per cent on the wet basis for summer firsts, compared with 0.0013 per cent for absolutely fresh eggs. These figures show well the difference in quality of the two grades of eggs.

TABLE 14.—*July and August firsts.*

[15-dozen lots.]

No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Percentage of moisture.
			20° C.	37° C.		Wet basis.	Dry basis.	
		1912.						
4802	F 5	July 22	Less than 1,000	Less than 1,000	10	0.0022	0.0072	69.59
4803	F 5	July 23	25,000	20,000	0	.0020	.0065	69.14
4966	F 6	Aug. 13	Less than 1,000	Less than 1,000	0	.0020	.0074	72.84
4967	F 6	...do.....	Less than 1,000	Less than 1,000	100	.....	.....	.....
4985	F 6	Aug. 15	92,000	1,000	0	.0019	.0068	71.87

SECONDS.

Seconds constitute a large proportion of the eggs used in the frozen and desiccated egg industry. In the spring, before the candling season begins, this grade consists of small, dirty, and oversized eggs sorted from receipts by inspection. After the first of June, when all incoming eggs are graded according to the condition of the contents, seconds also include shrunken eggs, hatch spots, weak eggs, heavy rollers, etc.

Since dirty shells during the process of opening contribute a special source of contamination to the liquid eggs, this class of eggs is considered separately in this dissertation.

During the interval between May 4 and August 30, 1912, 9 samples of whites, 9 of yolks, and 25 of whole eggs were taken from the product obtained from seconds, the different lots varying in size from 6 to 30 dozen eggs. During the process of breaking care was taken to discard all eggs which, from appearance or odor, were abnormal. The first five samples given in Table 15 under the section devoted to whole eggs, and the first four in the part assigned to whites and yolks, represent the product broken from small and oversized eggs. The maximum count of organisms per gram was 34,000 in the whole eggs and 85,000 in the whites and yolks.

The counts of the product from small and oversized eggs were no higher than those found in the liquid eggs broken from July and August firsts; in fact, the amount of ammoniacal nitrogen in the former was lower. The chemical results show, therefore, that the contents of the spring seconds were fresher than the summer firsts.

The samples taken after June 1, 1912, represent the small and oversized eggs sorted from receipts by inspection and also those showing incipient deterioration as observed by the candle. An observation of the laboratory results in Table 15 shows a general trend toward higher bacterial counts and greater amounts of ammoniacal nitrogen as the season advances.

TABLE 15.—*Seconds.*

WHOLE EGGS.

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Percentage of moisture.	Size of sample.	Remarks.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1912.								
4245	F 1	May 4	300	750	10	.....	.....	.....	15 dozen...	
4249	D 1	May 6	.....	1,100	10	0.0016	0.0048	66.23	...do.....	
4259	D 1	May 7	400	150	10	.....	.....	.....	...do.....	
4264	D 1	...do.....	34,000	400	0	.....	.....	.....	...do.....	
4411	D 2	May 27	23,500	17,000	10,000	.....	.....	.....	10 pounds.	
4578	D 3	June 19	600	300	0	.0016	.0059	73.00	6 dozen....	
4633	F 4	June 28	2,500	950	0	.0020	.0068	70.45	...do.....	
4694	D 4	July 9	27,500	21,000	1,000	.0021	.0079	73.35	12 dozen...	
4697	D 4	...do.....	5,200	300	0	.0021	.0075	71.81	.....	
4708	D 4	July 10	10,500	9,900	1,000	.0019	.0067	71.84	12 dozen...	
4710	D 4	...do.....	3,200	2,100	0	.0015	.0055	72.75	15 dozen...	
4803	F 5	July 22	110,000	93,000	100	.0023	.0083	72.38	...do.....	
4833	F 5	July 24	(1)	4,000	1,000	.0018	.0059	69.39	...do.....	
4945	E 6	Aug. 9	850,000	7,000	0	.0023	.0084	72.63	6 dozen....	
4957	F 6	Aug. 12	66,000	38,500	10	.0015	.0050	70.16	30 dozen...	
4972	F 6	Aug. 14	750,000	550,000	0	.0017	.0061	72.30	...do.....	
41002	D 6	Aug. 19	2,000	0 in 1,000	0	.0020	.0072	72.31	24 dozen...	
41018	D 6	Aug. 20	600,000	550,000	100	.0018	.0057	68.25	25 pounds.	
41019	D 6	...do.....	39,500	24,000	.....	.....	.....	.....	...do.....	
41029	D 6	Aug. 21	320,000	270,000	100,000	.....	.....	.....	...do.....	
41031	D 6	...do.....	500,000	500,000	100	.0017	.0061	72.53	24 dozen...	
41060	E 7	Aug. 26	1,800,000	700,000	10	.0020	.0074	72.98	30 dozen...	
41070	E 7	Aug. 27	3,600,000	1,600,000	10	.....	.....	72.78	...do.....	
41086	E 7	Aug. 30	430,000	55,000	100	.0026	.0095	72.56	...do.....	

[1] Less than 1,000.

TABLE 15.—*Seconds*—Continued.

WHITES AND YOLKS.

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Percentage of moisture.	Size of sample.	Remarks.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1912.								
4363	F 2	May 2	49,000	1,200	0	.....	.....	.....	15 dozen...	Whites.
4364	F 2	...do.....	85,000	1,600	0	.....	.....	.....	...do.....	Yolks of 4363.
4403	D 2	May 27	1,600	150	0	0.0004	0.0031	87.10	15 pounds.	Whites.
4404	D 2	...do.....	1,200	400	10	.0033	.0072	54.15	.....	Yolks of 4403.
4416	D 2	...do.....	60,000	20,000	100	.....	.....	.....	25 pounds.	Whites.
4417	D 2	...do.....	15,000	5,000	.....	.....	.....	.....	.....	Yolks of 4416.
4423	D 2	May 28	1,000	1,000	10	.0003	.0023	87.14	10 pounds.	Whites.
4424	D 2	...do.....	4,000	2,700	1,000	.0030	.0070	57.45	.....	Yolks of 4423.
4868	D 5	July 30	360,000	330,000	1,000	.....	.....	.....	13 pounds.	Whites.
4869	D 5	...do.....	110,000	90,000	(1)	.0037	.0083	55.42	11 pounds.	Yolks of 4868.
4977	F 6	Aug. 14	40,000	40,000	100	.....	.....	.....	20 pounds.	Whites.
4978	F 6	...do.....	130,000	130,000	0	.0037	.0087	57.25	...do.....	Yolks of 4977.
41005	D 6	Aug. 19	27,000	22,000	1,000	.....	.....	.....	.....	Whites.
41006	D 6	...do.....	300,000	180,000	1,000	.0029	.0067	56.66	15 pounds.	Yolks of 41005.
41011	D 6	...do.....	600,000	650,000	0	.0003	.0023	86.96	18 pounds.	Whites.
41012	D 6	...do.....	650,000	600,000	0	.0030	.0065	53.64	13 pounds.	Yolks of 41011.

[1] Less than 100.

The lowest number of bacteria found at 20° C. was 300 per gram in a sample taken during the early part of May, and the highest, 3,600,000, in a specimen obtained during the latter part of August. Of the 16 samples of whites and yolks none contained over 650,000 bacteria per gram; of the 24 lots of whole egg only about 8 per cent had more than 850,000. There were no *B. coli* in 14, or 35 per cent, and 100,000, or less, in the remaining samples. The percentage of ammoniacal nitrogen varied from 0.0015 per cent on the wet basis in spring seconds to 0.0026 per cent in summer seconds.

A larger number of eggs was discarded while breaking the summer and fall seconds than when opening analogous eggs in the spring.

It is probable that the organisms in the samples of liquid egg from seconds are referable partly to outside sources, but chiefly to the eggs themselves.

EGGS HAVING DIRTY SHELLS.

The highest percentage of dirty-shell eggs occurs during the wet spring weather. Since they do not keep well in storage, a large number find their way to egg-breaking establishments.

Table 16 gives the laboratory findings of six samples taken during May, June, and August, 1912. Fifteen dozen eggs were represented in one specimen and 6 dozen in the other five. All of the eggs were candled before opening. The number of eggs discarded during the process of breaking gives, perhaps, an index to the quality of the eggs in the different samples. Not more than three decomposed eggs were eliminated from the samples taken during May and June and not more than six from the two specimens broken in August.

TABLE 16.—*Eggs having dirty shells.*

[6 to 15 dozen lots.]

No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.
			20° C.	37° C.		Wet basis.	Dry basis.		
		1912.							*Dozen.*
4279	D 1	May 8	550,000	500,000	1,000	.....	.....	.....	15
4576	D 3	June 20	400	400	10	0.0017	0.0065	73.85	6
4581	D 3	...do....	13,000	3,000	1,000	.0017	.0063	72.87	6
4634	E 4	June 28	700,000	3,300	1,000	.0019	.0068	72.18	6
4947	E 6	Aug. 9	49,000	(1)	10,000	.0023	.0082	71.81	6
41087	E 7	Aug. 30	1,600,000	1,700,000	10	.0023	.0084	72.74	6

[1] Less than 1,000.

The bacterial contents were widely divergent; the minimum number was 400 and the maximum number 1,600,000 per gram at 20° C. The number of *B. coli* varied from 10 to 10,000 in the six samples. The amount of loosely bound nitrogen was markedly higher in the August samples than in the June samples.

Sample 41087 represents about the lowest quality of dirty eggs used by reputable breakers for food purposes. The shells were so filthy that dirty "dirties" (the trade designation) best describes them. The candle showed that they were shrunken eggs, and that many yolks floated near the shell as if they were about ready to adhere to it. The eggs eliminated during the process of opening were highly infected, as follows: One egg with a green white, one sour egg, one egg with yolk nearly mingled with white, and two eggs each with a broken yolk which had at one time been adherent to the shell. The conditions found in this lot of eggs are typical of low grade fall receipts.

The bacteria found in this series of samples were, without doubt, referable both to contamination from the shells during the process of opening and to the eggs themselves.

EGGS HAVING CRACKED SHELLS.

On account of the heavy losses accruing from shipping eggs having cracked shells, these eggs constitute one of the important classes used for breaking purposes.

During the interval between May 2 and August 26, 1912, 2 samples of whites, 2 of yolks, and 16 of whole eggs were taken. These samples represented lots of from 6 to 30 dozen cracked eggs, procured in D, E, and F houses, where it was the custom to keep "checks" in cool surroundings from the time of receipt until the time of breakage, and to give them precedence over other eggs in regard to promptness in candling and breaking. The laboratory results (see Table 17) from these samples indicate what is to be

expected from cracked eggs that are broken in the first concentrating center.

TABLE 17.—*Eggs having cracked shells.*

WHOLE EGGS.

Number.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.	Remarks.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1912.								
4215	F 1	May 2	600,000	600,000	0	0.0017	0.0056	70.28	15 dozen..	
4216	F 1	...do....	600	1,000	0	.0014	.0046	70.98	...do.....	
4242	F 1	May 3	500,000	300,000	10,000	.....	.....	.....	11 dozen..	
4254	D 1	May 6	750,000	490,000	100	.0016	.0052	69.14	15 dozen..	
4314	E 2	May 14	230,000	80,000	10,000	.....	.....	.....	12 dozen..	
4557	D 3	June 17	340,000	120,000	10,000	.0015	.0052	71.20	30 pounds.	
4572	D 3	June 19	140,000	75,000	0	.0019	.0071	73.22	6 dozen...	
4597	E 4	June 24	460,000	330,000	10	.....	.....	.....	13¾ dozen..	
4635	E 5	June 28	2,800	800	0	.0019	.0070	72.82	6 dozen...	
4711	D 4	July 10	700	400	10	.....	.....	.....	15 dozen..	
4827	F 5	July 24	2,200,000	1,800,000	10	.0021	.0068	69.02	...do.....	
4963	F 6	Aug. 13	35,000	35,000	10	.0018	.0065	72.51	...do.....	
4965	F 6	...do....	2,700,000	2,400,000	1,000	.....	.....	.....	...do.....	
4993	F 6	Aug. 16	50,000	38,500	1,000	.0018	.0065	72.29	...do.....	
4994	F 6	...do....	190,000	120,000	100	.....	.....	.....	...do.....	
41052	E 7	Aug. 26	2,300,000	950,000	1,000	.0023	.0074	69.01	30 dozen..	
			WHITES AND YOLKS.							
4218	F 1	May 2	36,500	1,400	100	0.0002	0.0016	87.36	30 pounds.	Whites.
4219	F 1	...do....	6,800	700	100	.....	.....	.....	...do.....	Yolks of No. 4218.
4282	D 1	May 8	13,500	15,000	1,000	.....	.....	.....	25 pounds.	Whites.
4283	D 1	...do....	25,000	64,000	1,000	.....	.....	.....	...do.....	Yolks of No. 4282.

Although the variation, shown in Table 17, in the number of bacteria in the different lots of cracked eggs was almost the same as that found in the samples of seconds, the individual counts in many instances were higher. For instance, 43.8 per cent of the samples of checks, as compared with 66.6 per cent of the samples of seconds, had counts under 200,000 per gram. The damaged shell of the checks offers less resistance to bacterial invasion than do sound shells, which factor explains the higher average count of cracked eggs. As was the case with the types of eggs previously discussed, the samples with the highest bacterial content were those which were taken during the month of August. The samples showed no greater deterioration chemically than did the specimens of summer firsts, seconds, and dirties.

Eggs with incipient odors but normal in appearance are very often found in some lots of cracked eggs, particularly in those which have not been chilled previous to opening. An examination of four single eggs gave counts of 12,000 bacteria per gram or less in three samples and of 1,200,000 in the fourth. There was no abnormality in the latter to distinguish it from the other three. A fifth sample

composed of five eggs with a similar but not strong odor contained 550,000 bacteria per gram and showed the low amount of ammoniacal nitrogen of 0.0016 per cent on the wet basis. Further tests are necessary before it can be positively stated whether the faint odor of warm cracked eggs is due to bacterial action or to absorption from surrounding materials. Experienced egg breakers recognize the characteristic odor of warm checks and do not discard them.

Quite different were the results of the examination of two individual eggs, the odor of which was suggestive of the products of bacterial growth. The eggs, normal in appearance, differed from each other only in the intensity of the odor. The count of the egg with the faint odor was 12,000,000, of the one with the strong odor 150,000,000. These eggs would be detected by careful grading and eliminated from a food product.

On account of the damaged shell, checks in a short time become infested with bacteria or molds or both. This result is hastened when the shells are soiled with the leakage from other eggs. From different lots of cracked eggs there were selected six samples consisting of from 4 to 12 eggs with moldy shells. No eggs were included unless the contents were normal in appearance, taste, and odor. Table 18 shows that there was a count of 160,000 in one sample and of from 1,200,000 to 12,000,000 in the other five. These results prove that even if the contents of cracked eggs with moldy shells smell, taste, and look good the egg substance is infected with bacteria as well as with molds.

TABLE 18.—*Cracked eggs with moldy shells opened commercially in packing house.*

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.	Description.
			20° C.	37° C.			Wet basis.	Dry basis.			
4217	F 1	1912. May 2	1,200,000	1,300,000	10	230,000	0.0019	0.0062	69.31	8 eggs..	Odor and taste good.
4241	F 1	May 3	2,700,000	1,700,000	10	15,000	.0013	.0043	68.26	12 eggs.	Do.
4398	D 2	May 27	4,000,000	3,100,000	100	0 in 1,000	.0019	.0058	67.17	8 eggs..	Odor good.
4583	D 3	June 20	8,600,000	5,400,000	100	40,000	.0021	.0070	70.18	4 eggs..	Do.
4596	E 4	June 24	12,000,000	5,900,000	0	0	.0025	.0088	71.76	.....	Do.
41022	D 6	Aug. 20	160,000	140,000	1,000	.....	.0019	.0064	70.23	6 eggs..	Do.
		MOLDY CRACKED EGGS COMPARED WITH NONMOLDY CRACKED EGGS.									
41036	D 6	Aug. 21	22,000,000	13,000,000	100,000	.....	0.0023	0.0078	70.39	11 lbs...	Moldy shells.
41037	D 6	Aug. 21	2,700,000	1,700,000	.....	.....	.0022	.0079	72.09	48 lbs...	Nonmoldy shells from same lot as 41036.

On one occasion a few cases of checks, a large percentage of which had moldy shells, were received at D house. The eggs for breaking were separated into two parts, one consisting of about 13 dozen moldy eggs and the other of about 60 dozen nonmoldy eggs. Every effort was made to eliminate all eggs abnormal in appearance or odor. On account of the number of times that it was necessary to wash hands and to change apparatus after bad eggs, it was a laborious task to separate the good from the bad. For example, there were 3 eggs with a bad odor, 4 rots, 5 sour eggs, and 14 eggs with a green white that were eliminated from the moldy lot. There were, as given in Table 18, 2,700,000 organisms in the nonmoldy and 22,000,000 in the moldy eggs. The quantity of ammoniacal nitrogen was practically the same in the two specimens, and was no higher than that found in some samples of summer firsts, seconds, and dirties. These results show that either the bacteria had not been present long enough or had not multiplied to a sufficient extent to materially change the composition of the egg substance.

The laboratory data from both the large and small samples show that for the preparation of a food product with a low bacterial content cracked eggs with moldy shells should be omitted.

EGGS HAVING THE YOLKS PARTIALLY MIXED WITH THE WHITES.

The class of eggs having the yolks partially mixed with the whites consists of three forms: One in which the yolk has seeped through the vitelline membrane in sufficient quantity to give a yellow tinge to the thick portion of the albumen; the second in which the yolk streams through small openings in the membrane into the white; and the third in which the yolk membrane breaks and allows the yolk to flow into the albumen. The first form can not be detected by the candling process; the second and third in many cases can be recognized by this method. During warm weather the vitelline membrane becomes thin and the white less viscous, which condition, accompanied by the jars occurring during transportation, causes the membrane to break and the contents of the yolk to escape. The cause of the seeping yolk in eggs is not understood. The three forms are the predecessors of the class of eggs called white rots, or eggs with white and yolk entirely mixed.

During the season of 1912, 10 samples, consisting of from 1 to 8 eggs, with yolks seeping into white were taken. The odor and taste of each were good. The results are shown in Table 19.

TABLE 19.—*Small samples of eggs with the yolks beginning to seep into the whites.*

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Percentage of moisture.	Size of sample.
			20° C.	37° C.			Wet basis.	Dry basis.		
		1912								*Eggs.*
4194	E 1	Apr. 25	2,600	3,900	0	0 in 10,000				3
4251	D 1	May 6	67,000	21,000	100	0 in 10,000	0.0017	0.0062	72.61	8
4266	D 1	May 7	100	400	0					1
4290	D 1	May 9	22,000,000	21,000,000	0	0 in 10,000	.0021	.0077	72.58	5
4357	E 2	May 17	100,000	21,000	10	900,000				2
4406	D 2	May 27	44,000	5,000	0	0 in 10,000	.0020	.0076	73.76	5
4428	D 2	May 28	300	100	0					2
4895	D 5	Aug. 2	3,900,000	3,500,000	0 in 100		.0023	.0078	70.54	5
41001	D 6	Aug. 19	0 in 10,000	0 in 10,000	0 in 100					1
41032	D 6	Aug. 21	17,000	7,500	10		.0018	.0072	74.98	4

Table 19 shows that the number of bacteria varied from 100 per gram at 20° C. to 100,000 in eight samples and from 3,900,000 to 22,000,000 in the other two. No explanation can be given of the cause of the last two counts other than that they may represent transitional stages between yolks beginning to mix and those entirely mixed with white. It was shown on page 30 that the latter are heavily infected with organisms. There were no *B. coli* in one-half of the specimens and only a few in the remaining half. The amount of protein deterioration was no greater than that found in seconds and cracked eggs.

Only three samples were taken of eggs with the yolk entering the white through small apertures in the vitelline membrane. The specimens consisted of individual eggs and were practically sterile.

During the latter part of July two samples were taken, consisting, in one case, of 30 dozen eggs, and in the other of 11 dozen, which, before the candle, appeared to have broken yolks but were otherwise normal. On opening the eggs it was found that the grading by the candle was not accurate, because among them was a large number of eggs which were approaching the stage of white rots. The large sample was opened without much care in grading; the smaller one was broken, and every egg which appeared to have passed the first stage of physical degeneration was eliminated. The difference between the laboratory results of the two samples was striking. The poorly graded sample contained 8,300,000 bacteria per gram, 1,000,000 *B. coli* per gram, and 0.0028 per cent of ammoniacal nitrogen on the wet basis; the well graded one, 5,500 organisms per gram, 10 *B. coli*, and 0.0021 per cent of loosely bound nitrogen. This experiment is a good example of the effect of careful and intelligent grading on a product prepared from doubtful eggs.

These preliminary studies indicate that eggs with yolks showing the first signs of deterioration are suitable for food purposes, if

other characteristics are normal, but that eggs showing more advanced decomposition should be avoided. This phase of the egg problem will be specially investigated during the season of 1913.

BLOODY WHITES.

Many of the first eggs laid by pullets contain blood which may be diffused through the white or may be in the form of clots on the yolk or in the albumen (see Pl. IV). It is probable that in the passage of the white and yolk through the oviduct some of the small blood vessels are ruptured, thereby allowing blood to gain access to the white or yolk before they are incased in a shell.

The examination of six individual eggs of this type disclosed the presence of less than 5,000 organisms per gram. No *B. coli* were found, except in one sample, which had only 10. The eggs were taken from the cups of the breakers; consequently the few organisms found are very likely referable to outside sources and not to the eggs. On account of the presence of blood, these eggs are not used for food purposes.

EGGS WITH BLOOD RINGS.

Eggs showing signs of incubation were discussed quite fully on page 13; consequently only the information gained when these eggs were broken commercially will be given here.

During May, 1912, four samples, consisting of from 3 to 12 large blood rings, were taken. Since the weather had not been warm enough to cause spontaneous development of embryos of fertile eggs, these blood rings were probably the result of the undesirable practice of selling incubated eggs which would not hatch. The yolks were broken and partially mixed with albumen; the germinal disk was deteriorated. The odor of each was good.

TABLE 20.—*Eggs with blood rings.*

LARGE SAMPLES OF EGGS WITH SMALL BLOOD RINGS.

Sample No.	Source.	Date of collection.	Number of bacteria per gram at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.	Remarks.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1912.								
4837	F 5	July 25	36,500	3,500	100	0.0022	0.0077	71.50	30 dozen..	Kept in chill room 2 weeks.
4843	F 5	July 26	37,000	37,000	10	.0022	.0077	71.60	12 dozen..	
4883	D 5	July 31	50,000	41,000	.....	.0019	.0067	71.56	8½ pounds.	
4889	D 5	Aug. 1	[1]0 in 1,000	[1]0 in 1,000	0	.0018	.0063	71.58	4 pounds..	
4960	F 6	Aug. 12	950,000	700,000	10,000	.0023	.0074	68.89	30 dozen..	
4975	F 6	Aug. 14	430,000	500,000	10	.0024	.0072	66.58	...do.....	
41033	D 6	Aug. 21	77,000	58,000	0	.0019	.0075	74.59	4½ pounds.	

[1] Less than 1,000.

TABLE 20.—*Eggs with blood rings*—Continued.

SMALL SAMPLES OF EGGS WITH LARGE BLOOD RINGS.

Sample No.	Source.	Date of collection.	Number of bacteria per gram at—		Number of gas-producing bacteria per gram in lactose bile.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.	Remarks.
			20° C.	37° C.		Wet basis.	Dry basis.			
		1912.								
4292	D 1	May 9	1,700	400	0	.....	.....	.....	3 eggs.....	Broken yolks.
4401	D 2	May 27	100	100	0	0.0014	0.0052	72.97	12 eggs....	Do.
4402	D 2	...do.....	400	750	10	.0016	.0059	72.71	...do.....	Do.
4430	D 2	May 28	100	150	0	.0019	.0070	72.71	5 eggs.....	Do.
4699	D 4	July 9	7,100,000	400	0	.0018	.0065	72.09	8 eggs.....	Do.

LARGE SAMPLES OF EGGS WITH LARGE BLOOD RINGS.

4838	F 5	July 25	4,000,000	1,900,000	100,000	0.0022	0.0077	71.41	30 dozen..	Kept in chill room 2 weeks.
4844	F 5	July 26	4,300,000	3,100,000	100	.0019	.0068	72.17	9 dozen...	
4884	D 5	July 31	0 in 1,000	0 in 1,000	.....	.0019	.0063	70.00	7½ pounds.	
4888	D 5	Aug. 1	6,500	0 in 1,000	10	.0019	.0063	69.96	10 pounds.	
41040	D 6	Aug. 22	2,000,000	1,400,000	10,000	.0020	.0071	71.98	7 pounds..	

The results of the first four samples given in the second section of Table 20 showed very few organisms and no *B. coli* except in one sample. The amount of ammoniacal nitrogen was identical with that found in contemporaneous samples of seconds, cracked, and dirty eggs. A fifth sample, taken in July, consisting of eight large blood rings, gave a count of 7,100,000 bacteria per gram on agar plates incubated at 20° C. and of 400 on similar plates kept at 37° C. The divergence of the two counts is not explained.

In July and August larger lots of both small and large blood rings were studied. These were caused in part by the warmth of the late summer months and in part by a short period of incubation under broody hens. The first observations were made of a case of blood rings which had been held in a chill room at about 32° F. for two weeks. The eggs were recandled and 8½ dozen eggs with broken yolks or with yolks stuck to the shell were discarded. During the process of breaking, the small and large blood rings were separated, the basis of division being less than 3 centimeters for the small and over that for the large blood rings. Many of the eggs of the former type had firm whites and yolks with faded rings. The eggs with the large blood rings contained broken yolks. All eggs showing signs of mixing of white and yolk, often termed "runny eggs," were excluded. Each lot was mixed thoroughly by passing a few times through a steamed sieve. The resulting mixtures had a good odor. The sample of small blood rings contained 36,500 bacteria per gram; the one

of larger blood rings, 4,000,000. The amount of ammoniacal nitrogen was in each case 0.0022 per cent on the wet basis.

The counts of similar samples of eggs with blood rings which had not been kept for any extended period in a chill room varied from less than 1,000 to 950,000 for small blood rings and from under 1,000 to 4,300,000 for large blood rings. Since the blood rings which were used in these samples underwent the same diversity of conditions before and during marketing as did the seconds, cracked eggs, dirty eggs, etc., they would be expected to show practically the same variations in bacterial contents.

The amount of loosely bound nitrogen in the samples of both small and large blood rings was no greater, and in many cases was less, than that found in stale eggs. These results are in accordance with those found by Pennington and Robertson,[1] which they summarize as follows:

> The amount of loosely bound nitrogen in incubated eggs, as determined by the Folin method, shows an interesting change. In the case of infertile eggs a very noticeable and quite regular increase takes place with time, while in the case of the fertile eggs the increase is very slight. Considering the content of loosely bound nitrogen as a criterion of protein decomposition, this is not surprising, since in the first case heat would be expected to increase catabolic processes, making for simpler nitrogen compounds, while in the second case it introduces metabolic or upbuilding processes.

The product obtained from eggs containing small blood rings was normal in appearance, taste, and odor; that obtained from eggs with large blood rings had a much lighter appearance; it was normal with respect to odor but had a flat, insipid, and uninviting flavor. It is evident, therefore, that changes had occurred which were recorded by the senses and not by the examinations just described. Pennington and Robertson found that catalase increased in fertile eggs during incubation, but did not increase in nonfertile eggs held under the same conditions. It may be that the studies now under way on the sugar content of eggs will also throw some light on the changes occurring in fertile eggs during the process of incubation.

EGGS WITH TURBIDITY IN THICK WHITE.

It is observed that when eggs which have been in storage for some time are broken, many of them have a turbidity which is localized in the thick portion of the albumen, but this cloudiness disappears when the eggs are warm. That this is a physical change brought about by low temperatures, and not by bacterial action, is indicated by the results given in Table 21 of the laboratory examination of six samples of eggs with cloudiness in the thick white.

[1] U. S. Dept. of Agr., Bureau of Chemistry Cir. 104.

TABLE 21.—*Eggs with turbidity in thick white.*

INDIVIDUAL EGGS.

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Size of sample.	Description.
			20° C.	37° C.				
		1912.					*Pounds.*	
4571	D 3	June 18	150	650	0	.....	.....	Leaking shell; normal yolk; no odor.
4575	D 3	June 19	43,500	36,500	100	2,000	.....	Do.
4587	D 3	June 22	150	100	0	.....	.....	Opened aseptically.
				SMALL SAMPLES.				
4598	E 4	June 24	120,000	32,000	10	100,000	4	Cracked eggs; normal yolk; good odor.
4611	E 4	June 25	16,000	500	0	.....	1.5	Cracked eggs and seconds; good odor.
4624	E 4	June 27	290,000	14,000	10	10,000	1	Dirty eggs; good odor.

EGGS HAVING WHITE PARTIALLY COAGULATED BY HEAT.

Breaking-stock eggs are occasionally found with contents which present the appearance of soft-boiled eggs. They probably had been dipped in hot water to prevent their use for hatching when they had been purchased, ostensibly for food purposes. The heat of summer is also, under some circumstances, sufficiently great to cause the albumen of eggs to partially coagulate, thus giving it a clouded appearance. For instance, an egg laid on a haystack exposed to the direct rays of the sun becomes partially cooked and has the appearance of an egg which has been in boiling water about a minute. A bacterial examination of two such eggs showed them to be practically free from organisms.

EGGS HAVING ENTIRE WHITE TURBID.

Bacterial growth in an egg may cause cloudiness in the albumen analogous to that caused by the growth of bacteria in laboratory media. The eggs may or may not have an odor. Eggs with a characteristic sour odor (see p. 61) have, almost invariably, a turbid albumen. An examination of four eggs with a clouded white showed (Table 22) that their bacterial content varied between 15,000 and 150,000,000 per gram. The two eggs with the high counts had an abnormal odor, which fact was indicative of the presence of large numbers of bacteria.

TABLE 22.—*Eggs having entire white turbid.*

[+ denotes presence.]

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Description.
			20° C.	37° C.			
533	F	1911. Aug. 4	5,600,000	3,400,000	100,000	+	Milky white; normal yolk; no odor.
4260	D 1	1912. May 7	13,000,000	8,300,000	100	0 in 10,000	Abnormal odor; normal yolk.
4331	E 2	May 16	150,000,000	120,000,000	10,000	+ in 100,000	Unpleasant odor; cloudy rim of white around yolk.
4766	E 5	July 17	15,000	4,800	100	.....	A very cloudy white; odor and taste good.

WHITE OR LIGHT ROTS.

White or light rots are the advanced forms of partly decomposed eggs, of which the following are typical: Eggs with yolk partially mixed with white, eggs containing old broken-down blood rings, and eggs with a broken yolk which was previously adherent to the shell. Before the candle these eggs are light in appearance, hence their name, and are often passed as good eggs by candlers who do not take the time to determine the condition of yolks. Out of the shell white rots appear as an unappetizing homogeneous mixture of yolk and albumen (see Pl. VII).

During the spring of 1912 six samples, composed of from four to eight white rots, were taken. The condition of these eggs had not been detected by candling, and they therefore found their way to the breaking room. Instead of being consigned to the rotten-egg bucket they were poured from the cups of the breakers into sample bottles. The laboratory examination showed that the majority of the samples were heavily infected with bacteria, among which were many *B. coli*. The results, which are given in Table 23, are in accordance with those obtained in the study of white rots opened under aseptic conditions. The percentage of ammoniacal nitrogen found in five of the six specimens was greater than that found in any of the previous samples discussed. The samples of summer firsts, seconds, checks, and eggs with yolk partially mixed with albumen contained from 0.0014 to 0.0026 per cent of loosely bound nitrogen on the wet basis, whereas the specimens of white rots gave a variation of from 0.0019 to 0.0061 per cent in the amount of ammoniacal nitrogen in five of the six samples examined.

TABLE 23.—*Eggs having the white entirely mixed with the yolk.*

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per centage of moisture.	Size of sample.
			20° C.	37° C.			Wet basis.	Dry basis.		
		1912.								*Eggs.*
4261	D 1	May 7	1,100,000	550,000	10	0 in 10,000	0.0025	0.0096	73.27	6
4291	D 1	May 8	14,000	10,000	1,000	0 in 10,000	.0019	.0072	73.63	5
4303	E 2	May 13	82,000,000	60,000,000	1,000,000	37,000,000	.0034	.0111	69.34	4
4318	E 2	May 14	110,000,000	9,100,000	1,000	22,000,000	.0033	.0109	69.68	6
4400	D 2	May 27	16,000,000	5,000,000	10	0 in 10,000	.0027	.0103	73.77	8
4459	E 3	June 1	56,000,000	24,000,000	1,000,000	15,000,000	.0061	.0211	71.17	.....

On account of the large number of bacteria which white rots contain it is very important that breaking stock be candled with sufficient care to prevent these eggs from gaining access to the breaking room.

EGGS HAVING THE YOLK ADHERENT TO THE SHELL.

Two different forms of summer eggs with adherent yolks, termed commercially "heavy spots," were found. One is caused by the action of high atmospheric temperatures and the other by exposure to damp surroundings. In some cases both factors contribute to the same result. Both types occur most frequently during the summer and autumn months.

The heavy spots caused by heat are found in the following stages: First, in which the yolk is so lightly stuck to the shell membrane that a slight jar sets it free (see Pl. VII); the second, in which the yolk is adherent and broken; and the third, in which a very small portion of yolk adheres to the shell, the rest being partially or entirely mixed with albumen. In the case of an incubated fertile egg, it is observed that the adherent surface of the yolk is the hatch spot or blood ring. The first and second types are usually without odor; the third may, or may not, have an odor, and is classed among the white rots on account of the mixing of yolk and albumen.

The eggs with an adherent yolk, produced by moisture, present a characteristic appearance before the candle. The portion of the yolk coming in contact with the shell is dark and often black in appearance. The yolk is much more opaque than normal. When the contents of these eggs are emptied from the shell, a large portion of the yolks cling to the shell. They have commonly a sour or putrefactive odor. This type of egg, if held for a sufficient length of time, may develop mold spots on the yolk.

Three samples with yolk very slightly stuck to the shell were selected by candling. When opened many of the yolks dropped out whole and left no mark on the shell at the place of contact (see

Pl. IV). During the breaking care was exercised to eliminate all eggs showing signs of mixing of white and yolk. For example, from Sample 4842 one egg was discarded; from 4891 twenty-two eggs, and from 4919 a larger number. The number of discards gives, perhaps, an index to the bacterial contents, for, as shown by Table 24, Sample 4842 contained 900,000 organisms per gram; Sample 4891, 8,300,000; Sample 4919, 24,000,000. The amount of ammoniacal nitrogen in the first sample was practically the same as that found in August checks, dirties, and seconds; the quantity in the other two samples was slightly higher. The odor and taste of the liquid product was good in every case.

TABLE 24.—*Small samples of eggs having the yolk adhering to the shell.*

Sample No.	Source.	Date of collection.	Number of bacteria per gram at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per centage of moisture.	Size of sample.
			20° C.	37° C.			Wet basis.	Dry basis.		
		1912.								
SLIGHTLY ADHERENT.										
4842	F 5	July 26	900,000	750,000	100	.....	0.0022	0.0077	71.37	6½ doz.
4891	D 5	Aug. 1	8,300,000	5,800,000	0	.....	.0024	.0088	72.72	4½ lbs.
4919	E 6	Aug. 6	24,000,000	2,700,000	100	.....	.0024	.0086	72.10	1 lb.
HEAVILY ADHERENT.										
4422	D 2	May 28	30,000,000	21,000,000	0	0 in 10,000	0.0049	0.0179	72.69	4 eggs.
4841	F 5	July 26	150,000,000	120,000,000	1,000,000	.....	.0031	.0108	71.25	5 doz.

For comparative study two samples of eggs with yolks heavily adherent to the shell and sometimes called by the trade "cellar stucks" were selected by candling. The portion of the yolk which clung to the shell when its contents were emptied was not removed. The product had an abnormal and offensive odor. Table 24 shows that the bacterial counts, as well as the percentage of ammoniacal nitrogen, were higher than those found in the first type, where the yolks were slightly adherent to the shell.

A sample of three eggs with adherent yolks, which had become moldy, contained 7,200,000 bacteria per gram and 0.0022 per cent of ammoniacal nitrogen. If this sample had included "moldy spots" with offensive odors the laboratory results would show much more decomposition.

Further studies will be made of spot eggs. The results cited, however, indicate that these eggs should not be used in a product prepared for food purposes.

BLACK ROTS.

Black rots receive their name from the black appearance which they present before the candle. Out of the shell they are a homogeneous olive green liquid with an offensive odor resembling that of hydrogen sulphid. It is often possible to pick out a black rot from receipts by the odor and grayish tint of the shell. The results of two samples consisting of from four to eight of these rots showed counts of more than a billion bacteria and an amount of ammoniacal nitrogen much greater than that found in any previous type of egg discussed (see Table 25). Black rots, therefore, represent eggs in the last stages of decomposition. Their only value is for fertilizer purposes.

TABLE 25.—*Small samples of black rots.*

Sample No.	Source.	Date of collection.	Number of bacteria per gram at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.
			20° C.	37° C.			Wet basis.	Dry basis.		
		1912.								
4421	D2	May 28	1,100,000,000	310,000,000	10,000,000	99,000,000	.....	.....	72.31	4 eggs.
4873	D5	July 31	2,300,000,000	2,300,000,000	10,000,000	.....	0.0229	0.0800	71.40	8 eggs.

DETERIORATED EGGS NOT DISTINGUISHABLE BY CANDLING.

The eggs previously discussed have been recognizable before the candle or distinguishable by other characteristics, such as dirty or cracked shells. Some eggs, however, which are distinctly undesirable, can not be detected by candling and must be eliminated by the breaker. These are recognized when out of the shell by color, odor, or general appearance. The great majority of them belong to three groups: Eggs having a green white, often called "grass" eggs by the trade; eggs having a pungent, characteristic odor, commonly known as "sour"; and eggs which are "musty," that is, having an odor which is exceedingly penetrating, very characteristic, and often suggesting that of the common jimson weed. This odor increases when heat is applied, so that a single musty egg in 100 pounds of good egg will spoil it for bakers' purposes.

A number of eggs have distinctive odors when out of the shell, though there may be no visible signs of deterioration. Sometimes the eggs absorb these odors, such as the fruity odor which comes when eggs and apples are held in a closed space together, or that of strawboard from the fillers in which they are packed. Unless these absorbed odors carry with them an objectionable taste there would seem to be no reason for discarding the eggs. Other odors, apparently

generated by the chemical changes accompanying deterioration, are indications that the egg is unfit for food.

The various groups of eggs not recognizable before the candle are productive of much trouble in the frozen and dried egg industry. They will therefore be considered separately.

EGGS HAVING GREEN WHITES.

Certain eggs show a distinctly greenish tinge in the white (see Pl. VIII). This may be so slight that it is not noticed unless compared with an egg having a normal color. The majority of these eggs show no other signs of deterioration; others have a thin albumen, a yolk with a ruptured membrane or even mixed to a decided extent with the white. Eggs showing macroscopic evidences of decomposition are usually accompanied by a fetid odor. The shells of eggs having green whites are frequently cracked, stained, or dirty; many have the appearance of washed eggs.

It is of interest to observe that these eggs are found in greatest numbers in the spring, when dirty and wet shells are most prevalent. Being but seldom distinguished by the candler while in the shell, they go to the breakers. Some plants have in the past excluded such eggs when the breaker happened to see them, especially if they had reached the odor stage. Other establishments used them when odorless and gave various reasons to account for the color, the most frequent explanation being that the hen had been eating grass. This supposition led to the term "grass egg" as descriptive of this condition, but as this phrase has been used by the trade to describe the early spring eggs also, much confusion has resulted.

Laboratory examination disclosed the fact that such eggs contain enormous numbers of bacteria, as is shown in Table 26.

TABLE 26.—*Eggs having green whites.*

I. INDIVIDUAL EGGS OPENED ASEPTICALLY.

Sample No.	Source.	Date of collection.	Number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Percentage of moisture.	Size of sample.	Description.
			20° C.	37° C.			Wet basis.	Dry basis.			
		1911.									
691	B	Sept. 12	220,000,000	3,300,000	1,000,000	.....	.....	.....	.....	.....	Light-green white; no odor.
693	B	Sept. 11	54,000,000	.....	0 in 100	.....	.....	.....	.....	.....	Bad odor.
4145	South.	Nov. 14	5,800,000	1,300,000	0 in 10	.....	.....	.....	.....	.....	Bad odor; dirty shell.
		1912.									
4639	E 4	June 29	35,000,000	1,500	0	0 in 100,000	.....	.....	.....	.....	A cracked egg.

II. INDIVIDUAL EGGS OPENED COMMERCIALLY.

		1911.									
631	B	Aug. 31	.....	9,600,000	0 in 1,000	.....	.....	.....	.....	.....	Dirty shell; very green white.
667	D	Sept. 7	7,500,000	10,000,000	0 in 1,000	.....	.....	.....	.....	.....	

III. SMALL SAMPLES OF EGGS WITH LIGHT-GREEN WHITES—ODORLESS—OPENED COMMERCIALLY.

WHOLE EGGS.

		1912.									
4817	F 5	July 23	49,000,000	23,000,000	10,000	.....	0.0027	0.0094	71.27	5 pounds.....	
4818	F 5	...do.....	61,000,000	55,000,000	100,000	.....	.0051	.0181	71.86	.....do.....	
4420	D 2	May 28	320,000,000	100,000,000	1,000,000	3,000,000	.0040	.0136	70.70	7 eggs.	

WHITES AND YOLKS SEPARATED.

		1912.									
4396	D 2	May 27	100,000,000	55,000,000	100,000	20,000,000	0.0007	0.0050	86.04	7 whites.....	
4397	D 2	...do.....	2,700,000	1,800,000	10,000	650,000	.0047	.0104	56.84	Yolks of 4396.....	
4504	F 3	June 11	210,000,000	210,000,000	100	30,000,000	.....	.....	.....	4 whites.....	
4505	F 3	...do.....	26,000,000	4,700,000	0	(1)	.....	.....	.....	Yolks of 4504.....	

IV. SMALL SAMPLES OF EGGS WITH GREEN WHITES—ODOR NOT BAD—OPENED COMMERCIALLY.

Whole Eggs.

		1912.									
4164	E 1	Apr. 22	51,000,000	4,100,000	10,000	.....	.....	.....	.....	2 quarts.....	
4165	E 1	...do.....	63,000,000	4,200,000	10,000	.....	.....	.....	.....	....do.....	
4193	E 1	Apr. 25	120,000,000	780,000	1,000	.....	.....	.....	.....	....do.....	
4221	F 1	May 2	110,000,000	23,000,000	10,000	400,000	0.0046	0.0143	67.82	4–5 eggs.....	
4250	D 2	...do.....	140,000,000	20,000,000	10,000	34,000,000	.0071	.0264	72.77	9 eggs.....	
4263	D 2	May 7	7,700,000	3,600,000	10,000	110,000	.0016	.0056	71.43	6 eggs.....	
4276	D 2	May 8	99,000,000	88,000,000	1,000,000	9,000,000	.0031	.0110	71.73	9 eggs.....	
4304	E 2	May 13	64,000,000	34,000,000	1,000,000	1,200,000	.0047	.0174	73.03	7 eggs.....	
4320	E 2	May 14	140,000,000	29,000,000	10,000	22,000,000	.0030	.0089	66.45	9 eggs.....	
4339	E 2	May 17	120,000,000	51,000,000	10	32,000,000	.0053	.0186	71.58	....do.....	
41076	E 7	Aug. 28	200,000,000	4,900,000	100	.....	.0067	.0223	69.89	4½ pounds.....	Dirty shelled; kept in cold storage 4 months.
4458	E 3	June 1	45,000,000	22,000,000	1,000	3,100,000	.0056	.0202	72.28	A few pounds.....	

Whites and Yolks Separated.

		1912.									
4306	E 2	May 13	60,000,000	23,000,000	1,000,000	20,000,000	0.0006	0.0045	86.78	12 whites.....	
4307	E 2	...do.....	33,000,000	18,000,000	.....	3,500,000	.0046	.0102	55.18	Yolks of 4306.....	
4329	E 2	May 15	58,000,000	1,200,000	100	10,000,000	.0009	.0068	86.71	10 whites.....	
4328	E 2	...do.....	27,000,000	1,900,000	10	9,000,000	.0040	.0085	53.03	Yolks of 4329.....	
4344	E 2	May 17	100,000,000	Spreaders.[2]	1,000	14,000,000	.0006	.0045	86.53	12 whites.....	
4345	E 2	...do.....	50,000,000	Spreaders.	10,000	18,000,000	.0046	.0100	53.89	12 yolks of 4344....	

[1] Present in 100,000.

[2] Spreaders are bacterial colonies which are characterized by their spreading growth on culture media.

The samples given in Part I of Table 26 were opened aseptically. The organisms found are, therefore, referable strictly to the egg. The other samples were obtained in packing houses and were opened into sterile cups. It is possible that a few extraneous organisms may, therefore, be included in these bacterial counts, but the error is small. There is a close agreement between maximum and minimum counts in the samples obtained by the two methods. While but 31 individual commercial samples were examined, many of them represent a large number of eggs and a few approximate 5 pounds each. Twenty-six of the 31 samples, or 83.9 per cent, show counts of over 10,000,000 per gram.

The predominating organism has been found to be *Pseudomonas syncyanea* (*Migula*)[1] and the color of the egg white is due to the ability of this form to produce a diffuse, green fluorescence in the medium in which it grows. When pure cultures of this pseudomonas were injected into a fresh egg the white assumed the characteristic color in a few days and later developed a fetid odor.

The pseudomonas is not, however, in pure culture when occurring in eggs with a green white. *B. coli*, as well as other organisms, are generally found with it. The numbers of *B. coli*, as determined by lactose bile fermentation, varied from 10 to 1,000,000 per gram.

The eggs which were physically in good condition and odorless, and some of which were separated into white and yolk, are listed in Table 26, Part III. Others, having an odor but not sufficient to preclude use according to old methods of grading, are given in Part IV. It will be observed that the white of the egg has a much greater number of organisms than the yolk, though the infection in the latter is also extensive. A further indication of a mixed infection is the fact that organisms which liquefy gelatin are commonly present in numbers. The pseudomonas isolated does not liquefy gelatin. It does not grow to any extent at 37° C.; yet the counts at this temperature are frequently decidedly higher than the sum of the number of liquefiers and the organisms developing in lactose bile with gas production. Apparently, therefore, these eggs with green-colored whites are recognized by the characteristic color produced by one species, though they are the harbingers of a number of species as well as of great numbers of organisms.

This argument is reenforced by the amount of loosely bound nitrogen found. When the egg is not separable into white and yolk the amount of nitrogen is uniformly high—much higher than in eggs commonly used for food. When the degeneration of the egg is not sufficient to interfere with its physical integrity the amount of loosely bound nitrogen is not materially increased. It might

[1] This organism was identified by Evelyn Witmer, of the staff of the Food Research Laboratory.

be inferred from these facts that even though the number of bacteria in the egg be very high, as, for example, in Sample 4504, where 210,000,000 per gram were found, the infection is too recent to have produced chemical changes in the nitrogenous constituents. Because of the mixed infection it is not possible to correlate the amount of loosely bound nitrogen with the presumably greater or lower number of pseudomonas individuals, since the accompanying organisms may exercise even greater activity in splitting protein molecules.

SOUR EGGS.

The term "sour eggs," or "sour rot," is used by the egg breaker to describe an egg that has when opened a peculiar pungent odor. In the sense of a vinegar or common acid odor these eggs, in the earlier stages at least, do not fit the name. In the later stages they may have an odor suggesting sourness in the usual acceptance of the term. They are characterized by causing a prickling sensation in the nose, suggesting the bite of pepper, though not so sharp nor so well defined. These eggs can not be distinguished by candling. Generally, however, there is some visible sign of degeneration as well as the characteristic pungency. For example, sour eggs frequently have a turbidity in the white, or the yolk membrane may be weak, or even broken, so that the yolk is more or less mingled with the white. The only means of detecting such an egg is the peculiar pungent odor.

Table 27 gives the bacterial and chemical analyses of 18 samples of sour eggs. The samples vary in size from 2 eggs to 5 pounds. All were obtained from the current egg supply in the several packing houses, were broken by cracking on a sterilized knife edge, and were emptied into a sterilized glass cup. The grading was such that the eggs in one lot were as nearly identical as possible.

TABLE 27.—*Sour eggs.*

I. SMALL SAMPLES OF EGGS WITH FAINTLY SOUR ODOR.

Sample No.	Source.	Date of collection.	Total number of bacteria per gram on plain agar incubated at—		Number of gas-producing bacteria per gram in lactose bile.	Gelatin liquefying organisms per gram.	Percentage of ammoniacal nitrogen, Folin method.		Per cent of moisture.	Size of sample.	Description.
			20° C.	37° C.			Wet basis.	Dry basis.			
		1912.									
4427	D 2	May 28	430,000,000	430,000,000	10,000,000+	.....	.....	.....	.....	2 eggs.....	White and yolk intact.
4460	E 3	June 1	89,000,000	73,000,000	1,000,000+	4,400,000	0.0038	0.0141	73.00	.....	Do.
4530	F 3	June 13	380,000,000	440,000,000	10,000	.....	.0052	.0194	73.19	5 eggs.....	Soft yolks.
4815	F 5	July 23	140,000,000	97,000,000	1,000,000+	.....	.0032	.0113	71.57	5 pounds....	
4816	F 5	...do.....	160,000,000	130,000,000	10,000,000+	.....	.0030	.0122	75.48	.....do.....	
4836	F 5	...do.....	130,000,000	120,000,000	1,000,000+	.....	.0046	.0151	69.52	2½ pounds...	

II. SMALL SAMPLES OF EGGS WITH DISTINCTLY SOUR ODOR.

WHOLE EGGS.

4256	D 1	May 6	800,000,000	350,000,000	1,000,000+	1,000,000	0.0098	0.0323	69.70	5 eggs.....	White intact; some yolks broken, others soft.
4262	D 1	May 7	270,000,000	170,000,000	1,000,000+	16,000,000	.0040	.0141	71.66	.....do.....	Do.
4281	D 1	May 8	170,000,000	85,000,000	1,000,000+	6,000,000	.0043	.0153	71.91	6 eggs.....	Do.
4288	D 1	May 9	98,000,000	130,000,000	1,000,000+	50,000,000	.0029	.0102	71.47	.....	Peculiar turbid white; some yolks broken, others soft.
4321	E 2	May 14	300,000,000	230,000,000	1,000,000+	8,000,000	.0036	.0125	71.19	6 eggs.....	
4330	E 2	May 15	200,000,000	180,000,000	1,000,000+	(1)	.0038	.0136	72.11	7 eggs.....	
4343	E 2	May 17	70,000,000	11,000,000	1,000,000+	18,000,000	.0029	.0102	71.52	8 eggs.....	Partially curdled white; soft yolk.

WHITES AND YOLKS SEPARATED.

41016	D 6	Aug. 19	320,000,000	160,000,000	10,000,000+	.....	0.0005	0.0037	87.07	8–10 eggs....	Whites.
41017	D 6	...do.....	160,000,000	92,000,000	10,000,000+	.....	.0034	.0075	54.91	.....do.....	Yolks.

III. INDIVIDUAL EGGS WITH DECIDEDLY SOUR ODOR.

[2] 4269	D 1	May 7	1,200,000,000	160,000,000	1,000,000+	50,000,000	.....	.....	.....	.....	A sour and yeasty odor; some white intact, yolk broken.
4338	E 2	May 17	600,000,000	6,500,000	1,000,000+	([1])	.....	.....	.....	.....	A sour and yeasty odor; white and yolk mingled.
4757	E 5	July 16	410,000,000	240,000,000	1,000,000+	.....	.....	.....	.....	.....	

[1] Present in 1,000,000.

[2] Yeast cells present.

All the samples examined show a high count of bacteria. One sample (4269) has more than a billion organisms per gram and all the samples but three have more than 100,000,000. On the score of numbers of bacteria these eggs rank with black rots. The table gives first a series of eggs in which the odor is but faint and which might easily be passed by the careless or too rapid grader. Part II gives another series in which the odor was distinct and Part III gives three samples in which the odor was pronounced. It will be noted that these last three samples are individual eggs, and that a physical deterioration in two of the three has proceeded so far that the vitelline membrane has ruptured.

The bacterial content of the eggs with a faintly sour odor and those with a distinctly sour odor is about the same, with the exception of Sample 4256, in which the bacterial count agrees with the eggs in Part III in having a decidedly sour odor.

The great number of organisms invariably present is, however, the noteworthy feature. Aside from the numbers of organisms, the *Bacillus colon* was found in every sample examined, a condition which, up to this time, has not been observed for any other single type of deteriorated egg. Not only are *B. coli* present, but the number, as determined by lactose bile fermentation, is usually at least a million, and may be 10 million. In some of the samples listed as showing a million, more may have been present, because the dilutions were not made beyond this point. Had they been it is quite probable that the coli organisms would have been found to be more numerous than the analyses indicated. One sample (41016) was separated into whites and yolks. The count in the whites is double that in the yolks, which may indicate an infection from the exterior, though more work must be done with the two portions of the egg before accepting this suggestion as a fact.

Where organisms liquefying gelatin were sought they were found and in comparatively large numbers. Hence, there is in these eggs a condition very much like that noted in the eggs with a green white, namely, a mixed infection aggregating large numbers of individual organisms and characterized by the presence of one distinguishing species.

The amount of loosely bound nitrogen is higher than that commonly observed in seconds, which, on the average, is 0.0067 per cent on the water-free basis. The range, omitting Sample 4256, which is exceptionally high, is from 0.0102 to 0.0194 per cent, with an average of 0.0134 per cent, all these values being on the water-free basis. The water content of the samples varies from 69.52 to 75.48 per cent, indicating a decided variation in the age of the eggs as measured by shrinkage.

MUSTY EGGS.

The eggs called musty by the bakers have a strong odor, very penetrating and persistent, becoming more pronounced when heat is applied. All such eggs are sharply watched for by egg breakers and discarded. Fortunately they are not very plentiful, even in the early spring and late summer, when they are most common. Hot, dry weather seems to lessen their frequency.

Sometimes several musty eggs will be found in the same lot; very rarely almost a whole case of eggs will be of this type. They can not be recognized by the candler and very frequently there is no physical sign to indicate that the egg is not good. The sense of smell alone must be depended upon to detect them.

The few examinations made of musty eggs do not justify any conclusions; therefore they are not given here. It is highly desirable that further and detailed studies be made of this type of egg, which is interesting from practical and scientific viewpoints.

SUMMARY.

BACTERIOLOGICAL RESULTS OF INDIVIDUAL EGGS OPENED ASEPTICALLY IN THE LABORATORY.

The first section of Table 28, summarizing the total bacterial contents of individual eggs opened aseptically in the laboratory, shows that the greatest percentage of second-grade food eggs examined, the medium stale eggs, hatch-spot eggs, heavy rollers, dirty eggs, cracked eggs, and eggs with yolk partially mixed with albumen, contained less than 1,000 bacteria per gram. The occasional high bacterial content of single cracked eggs, dirty eggs, etc., could, in most instances, be predicted by the appearance of the shell or by the odor and condition of the contents. Such eggs would ordinarily be recognized and discarded by the housewife or egg breaker.

The second section discloses the rather unexpected fact that *B. coli* were not present in the whole-shelled second-grade eggs and were present in only 5.9 per cent of the cracked-shelled eggs.

Blood rings and the last five types of eggs given in the two sections represent eggs ordinarily discarded as unfit for food purposes. The first section shows that 26.5 per cent of the eggs with adherent yolks, 50 per cent of the eggs with dead embryos, 75.9 per cent of the moldy eggs, 66.7 per cent of the white rots, and 100 per cent of the black rots contained over 1,000 organisms per gram. A review of the second section of the table shows that, with the exception of the white and black rots, *B. coli* were present in but few of the eggs.

TABLE 28.—*Summary of bacteriological results of individual eggs opened aseptically in the laboratory.*

NUMBER OF ORGANISMS PER GRAM.

Type of egg.	Portion of egg examined.	0 to 10, inclusive.		11 to 100, inclusive.		101 to 1,000, inclusive.		1,001 to 10,000, inclusive.		10,001 to 50,000, inclusive.		50,001 to 100,000, inclusive.		100,001 to 500,000, inclusive.		1,000,001 to 5,000,000, inclusive.		5,000,001 to 10,000,000, inclusive.		10,000,001 and over.		Total.
		Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	
Medium stale eggs	White	7	77.7	2	22.2																	9
	Yolk	9	100.0																			9
Hatch spot eggs	White	4	36.4	6	54.5	1	9.1															11
	Yolk	4	50.0	2	25.0	2	25.0															8
	Whole egg	2	22.2	6	66.6	1	11.1															9
Small blood rings	White	6	75.0	1	12.5	1	12.5															8
	Yolk	5	62.5	1	12.5	2	25.0															8
	Whole egg	3	33.3	6	66.6																	9
Cracked eggs	White	7	25.8	14	51.7	2	7.5	1	3.8					2	7.5					1	3.8	27
	Yolk	6	23.0	13	50.0	4	15.4							1	3.8	1	3.8			1	3.8	26
	Whole egg	6	21.4	17	60.7	4	14.2													1	3.6	28
Heavy rollers	White	3	50.0	3	50.0																	6
	Yolk			5	100.0																	5
	Whole egg			22	88.0							2	8.0	1	4.0							25
Dirty eggs	White	23	45.1	14	27.4	7	13.7	4	7.8			1	2.0			1	2.0			1	2.0	51
	Yolk	9	25.6	12	34.2	8	22.8	4	11.4							1	2.8	1	2.8			35
Eggs with yolk partially mixed with white.	Whole egg	8	47.1	7	41.1							1	5.9			1	5.9					17
Yolks stuck to shell	White	22	62.9	5	14.3	1	2.8							1	2.8	1	2.8			5	14.3	35
	Yolk	8	27.5	9	31.0	2	6.9	1	3.4			1	3.4	2	6.8	2	6.8	1	3.4	3	10.3	29
	Whole egg	1	25.0	2	50.0											1	25.0					4
Eggs with dead embryos.	do			1	12.5	3	37.5	1	12.5			1	12.5	1	12.5					1	12.5	8
Moldy eggs	White			4	23.5	3	17.6	2	11.7	1	5.9	1	5.9	1	5.9			5	29.4			17
	Yolk			1	7.7			1	7.7	2	15.4	1	7.7	2	15.4	1	7.7	5	38.5			13
	Whole egg	2	8.3	1	4.2	2	8.3	4	16.5	6	25.0	3	12.5	3	12.5	2	8.3	1	4.2			24
White rots	do	2	16.6			2	16.6							1	8.3			1	8.3	6	50.0	12
Black rots	do																			10	100.0	10
Total		137		154		45		18		9		11		15		11		14		29		443

NUMBER OF GAS-PRODUCING ORGANISMS PER GRAM IN LACTOSE BILE.

Type of egg.	Portion of egg examined.	0		10		100		1,000		10,000		100,000		1,000,000		Total number of samples.
		Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	
Medium stale egg	White	3	100.0													3
	Yolk	3	100.0													3
Hatch spot eggs	White	9	100.0													9
	Yolk	9	100.0													9
	Whole egg	5	100.0													5
Small blood rings	White	7	100.0													7
	Yolk	7	100.0													7
	Whole egg	10	100.0													10
Cracked eggs	White	20	90.9			[1] 1	4.5					[1] 1	4.5			22
	Yolk	20	90.9			[1] 1	4.5					[1] 1	4.5			22
	Whole eggs	28	96.5							[1] 1	3.5					29
Heavy rollers	White	6	100.0													6
	Yolk	5	100.0													5
Dirty eggs	White	35	100.0													35
	Yolk	35	100.0													35
Eggs with yolk partially mixed with albumen.	Whole egg	14	100.0													14
Eggs with yolk stuck to shell.	White	22	91.6	2	8.3											24
	Yolk	22	88.0	3	12.0											25
	Whole egg	2	100.0													2
Eggs with dead embryos	do	7	87.5					1	12.5							8
Moldy eggs	White	6	75.0	1	12.5	[1] 1	12.5									8
	Yolk	5	83.3			[1] 1	16.7									6
	Whole egg	13	100.0													13
White rots	do	5	55.5			[1] 1	11.1			3	33.3					9
Black rots	do	1	20.0			1	20.0							3	60	5
Total		299		6		6		1		4		2		3		321

[1] No higher dilution made.

BACTERIOLOGICAL AND CHEMICAL RESULTS OF COMPOSITE SAMPLES OF EGG OPENED COMMERCIALLY IN THE PACKING HOUSE.

The laboratory results of composite samples of eggs opened commercially in the packing house are summarized in Tables 29 and 30 and are shown graphically in figures 1 and 2. From these data the following conclusions are drawn:

(1) The samples of July and August firsts contained very few organisms, and in many cases no bacteria of the *B. coli* group.

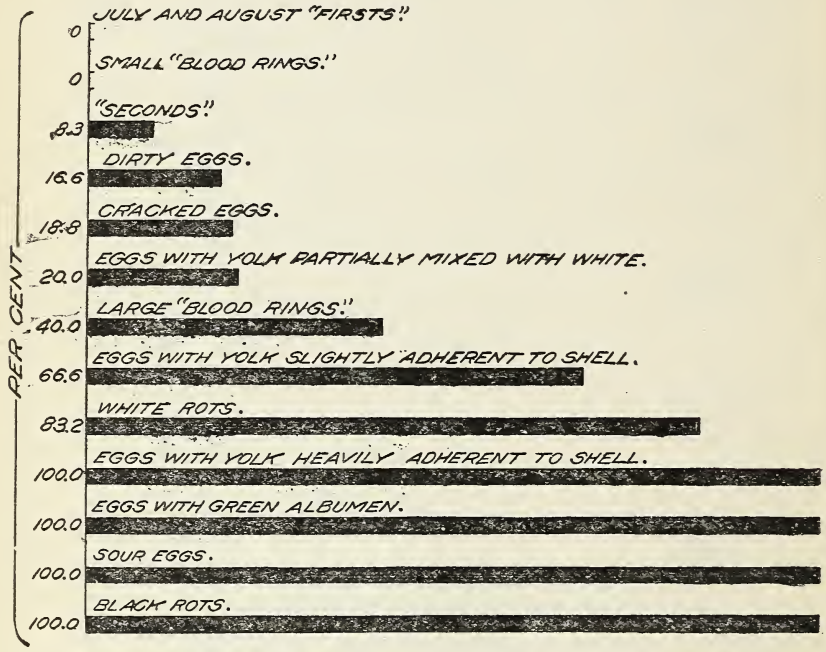

FIG. 1.—Percentage of samples opened commercially with bacterial counts over 1,000,000 per gram.

(2) The majority of the samples of clean-shelled seconds had a comparatively low bacterial content, only 8.3 per cent of them containing over 1,000,000 organisms per gram. The number of *B. coli* varied in the different specimens from none to 100,000 per gram.

(3) The percentage of bacterial counts over 1,000,000 per gram in samples of dirties, checks, and eggs with yolk partially mixed with albumen was 16.6, 18.8, and 20 per cent, respectively. No greater number of *B. coli* was found in these samples than in samples of seconds.

(4) The samples of blood rings contained comparatively few organisms. The large blood rings in most instances showed more infection than did the small rings. Most of the specimens contained less than 10 *B. coli* per gram.

(5) The amount of protein decomposition as shown by the ammoniacal nitrogen in the preceding six types of eggs was greater, as would be expected, than that found in strictly fresh eggs, but was no greater than that found in some grocery eggs. Although a cracked

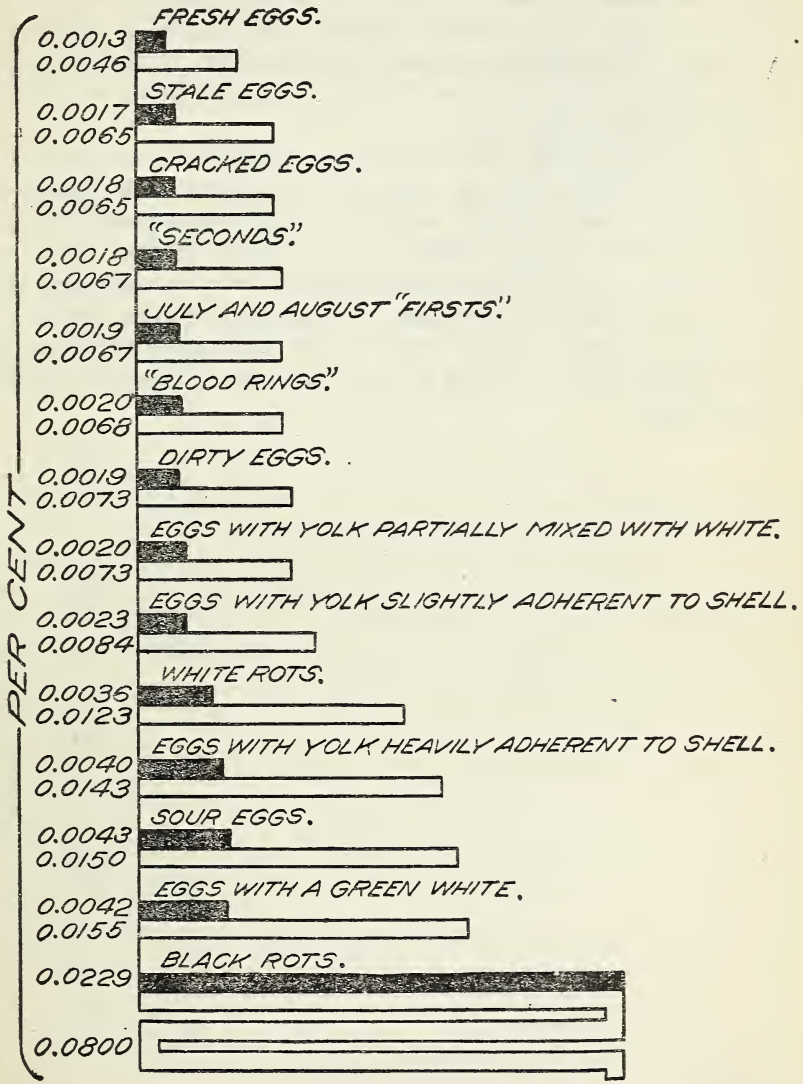

FIG. 2.—Average amount of ammoniacal nitrogen in 14 types of eggs (closed bars, fresh basis; open bars, dry basis).

or dirty shell may be a factor in facilitating infection and subsequent decomposition, the data obtained show that checks and dirties in the producing section are as well preserved as the clean whole-shelled seconds or the July and August firsts.

(6) The eggs constituting the samples of July and August firsts, seconds, dirties, and checks would be used without compunction by the housewife, baker, or confectioner.

(7) The majority of the samples of white rots, eggs with yolk lightly adherent to the shell, and all of the samples of sour eggs, black rots, eggs with a green albumen, and eggs with yolk heavily adherent to the shell, were infested with bacteria. *B. coli* were present in most of these samples, forming the predominating organism in the samples of sour eggs.

(8) The eggs with the yolk lightly adherent to the shell were, chemically, slightly lower in quality than were the second-grade food eggs, whereas the sour eggs, white rots, eggs with a green white, and eggs with yolk heavily adherent to the shell showed much more deterioration. Black rots had five times as much ammoniacal nitrogen as any of these types of eggs. With the exception, possibly, of the eggs with yolks lightly stuck to the shell, none of the eggs in these samples would be used by the housewife or reputable baker or confectioner.

TABLE 29.—*Summary of bacteriological results of eggs opened commercially in the packing house.*

I. TOTAL NUMBER OF ORGANISMS PER GRAM.

Type of egg.	0 to 10,000, inclusive.		10,001 to 50,000, inclusive.		50,001 to 100,000, inclusive.		100,001 to 500,000, inclusive.		500,001 to 1,000,000, inclusive.		1,000,001 to 5,000,000, inclusive.		5,000,001 to 10,000,000, inclusive.		10,000,001 and over.		Total number of samples.	Total number of dozens examined.
	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.		
July and August firsts	3	60	1	20	1	20											5	75
Seconds	9	37.5	5	20.8	1	4.2	4	16.6	3	12.5	2	8.3					24	429
Cracked eggs	3	18.8	2	12.5			6	37.5	2	12.5	3	18.8					16	244
Cracked eggs with moldy shells							1	16.6			2	33.3	1	16.6	2	33.3	6	14
Dirty eggs	1	16.6	2	33.3					2	33.3	1	16.6					6	45
Eggs with yolk partially mixed with white	4	40	2	20	2	20					1	10			1	10	10	3
Small blood rings	1	14.3	3	42.8	1	14.3	1	14.3	1	14.3							7	119
Large blood rings	6	60									3	30	1	10			10	67
Eggs with yolk slightly adherent to shell									1	33.3	1	33.3	1	33.3			3	12
Eggs with yolk heavily adherent to shell															2	100	2	5
White rots			1	16.6							1	16.6			4	66.6	6	3
Eggs with a green white													4	19	17	80.9	21	52
Sour eggs															18	100	18	15
Black rots															2	100	2	1
Total	27		16		5		12		9		14		7		46		136	1,084

TABLE 29.—*Summary of bacteriological results of eggs opened commercially in the packing house*—Continued.

II. NUMBER OF GAS-PRODUCING ORGANISMS PER GRAM IN LACTOSE BILE.

Type of egg.	0.		10.		100.		1,000.		10,000.		100,000.		1,000,000.		10,000,000 and over.		Total number of samples.
	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	Number of samples.	Per cent.	
July and August firsts	3	60	1	20	1	20											5
Seconds	8	34.8	6	26.1	4	17.4	3	13.1	1	4.3	1	4.3					23
Cracked eggs	4	25	4	25	2	12.5	3	18.75	3	18.75							16
Cracked eggs with moldy shells	5	62.5	2	25	1	12.5											8
Dirty eggs			2	33.3			3	50	1	16.6							6
Eggs with yolk partially mixed with white	5	62.5	2	25	1	12.5											8
Small blood rings	2	33.3	2	33.3	1	16.6			1	16.6							6
Large blood rings	4	44.4	2	22.2	1	11.1			1	11.1	1	11.1					9
Eggs with yolk slightly adherent to shell	1	33.3			2	66.6											3
Eggs with yolk heavily adherent to shell	1	33.3			1	33.3							1	33.3			3
White rots	2	33.3			2	33.3					2	33.3					6
Eggs with a green white	1	5.9	1	5.9	1	5.9	2	11.7	7	41.2	1	5.9	4	23.5			17
Sour eggs									1	6.2					15	93.8	16
Black rots															2	100	2
Grand total	36		22		17		11		15		5		5		17		128

TABLE 30.—*Variation in amount of ammoniacal nitrogen in 17 types of eggs.*

Kind of eggs.	Number of samples.	Per cent of ammoniacal nitrogen, Folin method.	
		Wet basis.	Dry basis.
Fresh eggs	6	0.0011–0.0015	0.0040–0.0054
July and August firsts	4	.0019– .0022	.0065– .0074
Grocery eggs	10	.0010– .0022	.....
Stale eggs	3	.0016– .0018	.0061– .0069
Seconds	17	.0015– .0026	.0048– .0095
Cracked eggs	18	.0014– .0024	.0046– .0083
Cracked eggs with moldy shells	7	.0013– .0025	.0043– .0088
Dirty eggs	14	.0013– .0024	.0061– .0084
Eggs with yolk partially mixed with white	5	.0017– .0023	.0062– .0078
Small blood rings	7	.0018– .0024	.0063– .0077
Large blood rings	9	.0014– .0022	.0052– .0077
Eggs with yolk slightly adherent to shell	3	.0022– .0024	.0077– .0088
Eggs with yolk heavily adherent to shell	2	.0031– .0049	.0108– .0179
White rots	6	.0019– .0061	.0072– .0211
Eggs with green whites	12	.0016– .0071	.0056– .0264
Sour eggs	12	.0029– .0098	.0102– .0323
Black rots	1	.0229	.0800
Total	136	.....	.....

A COMPARISON OF BACTERIAL CONTENTS OF INDIVIDUAL EGGS OPENED ASEPTICALLY WITH THOSE OF EGGS OPENED COMMERCIALLY.

A comparison of the results of individual eggs opened aseptically with the results of composite samples of eggs opened under clean commercial conditions shows some apparent discrepancies. For instance, only 4, or 7.1 per cent, of the 56 individual cracked eggs opened aseptically contained over 1,000 organisms per gram, whereas 14, or 87.5 per cent, of the 16 composite samples, representing 2,924 "checks," opened commercially contained more than this number per gram.

It will be observed that the numbers of the latter are far in excess of the former; it will be remembered, also, that eggs vary greatly among themselves. It is possible, therefore, that the differences between the bacterial findings of individual eggs and composite samples are due, in large part, to the relative difficulty in detecting early stages of infected eggs.

It was possible, for instance, to detect by the senses[1] but two of the four individual cracked eggs which were infected. It has been shown in Tables 26 and 27 that incipient sour eggs, which are detected only by the sense of smell, and eggs with albumen just beginning to turn green, which are recognized only by the sense of sight,

[1] To determine definitely to what extent it is possible to detect infected eggs by means of the senses, and to what extent the bacterial content of a product consisting of large numbers of eggs of unknown history can be minimized by grading, it is necessary to make detailed descriptions of the characteristics of many individual eggs, to open each aseptically and to determine their bacterial content singly and in combination. To find, also, the amount of bacterial contamination acquired during the preparation, studies must be made of the routine methods in use in egg-packing houses to determine the part which each step in the process of preparation plays in the final condition of the product. This subject will be presented as the second report of this series.

contain millions of organisms. It is reasonable to conclude, therefore, that the earlier forms of such and similar eggs furnish large numbers of bacteria to the liquid product prepared from second-grade food eggs. It is quite probable, also, that these earlier stages of incipient sour eggs are a contributing cause to the presence of appreciable numbers of *B. coli* in liquid egg of good quality.

TECHNIQUE FOR THE BACTERIOLOGICAL EXAMINATION OF EGGS.

METHODS USED FOR OBTAINING SAMPLES OF INDIVIDUAL EGGS OPENED ASEPTICALLY IN THE LABORATORY.

A. Mercuric chlorid method.[1]—The eggs were washed in running water, treated for five minutes in a 1 to 500 or 1 to 1,000 mercuric chlorid solution, and then rinsed with sterile water. The egg was then placed, large end uppermost, in a suitable holder. A small opening was made in the apex with sterile, fine-pointed forceps, about 2 square centimeters of the shell removed, and the membrane punctured. About 2 cc of the white were then transferred with a sterile pipette to a sterile tared weighing flask containing small pieces of sterile glass. The opening was made larger and as much of the white as possible removed with the pipette. With a second sterile pipette the vitelline membrane was ruptured, and about 2 cc of the yolk transferred to another weighing flask. When it was impossible to examine white and yolk separately, on account of disintegration, a sample of whole egg was taken.

B. Flaming method.[2]—The egg was washed in running water, rinsed in sterile water, dried with a sterile towel, and placed, large end uppermost, in a suitable holder. The top of the egg was sterilized by flaming. A portion of the top was removed with fine-pointed forceps and the contents of the egg dropped into a sterile salt-mouthed 4-ounce bottle containing sterile glass.

PREPARATION OF COMPOSITE SAMPLES OF EGGS OPENED COMMERCIALLY IN THE PACKING HOUSE.

The details of the collection and handling of the samples are described on page 39. When the samples arrived in the morning, they were examined immediately. When they came late in the day, they were put at once into a sharp freezer and held overnight. On arrival at the laboratory the hard-frozen samples were placed immediately in a water bath at 40° C. and allowed to remain, with frequent shaking, until completely melted. After shaking the melted sample vigorously for five minutes, about 3 cc were transferred with a sterile pipette to a tared weighing flask.

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[1] Samples 4001 to 4159, inclusive, and 3001 to 3030, inclusive, were obtained by this method.

[2] Samples with numbers under 1,000 were obtained by this routine.

METHOD OF PLATING AND COUNTING.

The flask containing the portion for examination was weighed. The weight of egg material in grams multiplied by 9 gave the number of cubic centimeters of sterile physiological salt solution required to make a 1 to 10 dilution, the slight error due to the gravity of the egg material being disregarded. After very thorough shaking, 1 cc of the 1 to 10 dilution was transferred by means of a sterile pipette to 9 cc of sterile physiological salt solution, thereby obtaining a 1 to 100 dilution. Higher dilutions were made on the same plan. Two duplicate series of plates of nutrient agar were prepared from four consecutive dilutions. One set was incubated at 37° C. for two days; the other for five days at 20° C.

The history of the sample was used as a basis for deciding in each case which dilutions should be plated. Whenever possible plates containing from 50 to 250 colonies were selected for counting. The numerical results were expressed in accordance with the rules prescribed by American Public Health Association, 1912. A Stewart's counting chamber and a hand lens, magnifying four or five diameters, were used to facilitate the counting. To determine the sterility of the media, the salt solution, and glassware, blank plates were poured at each plating. Plates of agar were also exposed to the air for three minutes during each plating to show the relative freedom from air contamination.

DETERMINATION OF THE NUMBER OF ORGANISMS CAPABLE OF LIQUEFYING GELATIN.

In a number of the experiments to be reported an attempt was made to determine the gelatin liquefying organisms quantitatively. For this purpose gelatin plates were prepared at the same time and in the same manner as the agar plates. These were incubated at 20° C. and the liquefying colonies counted at the most appropriate time. The counts were so discordant that many of the results were discarded. The difficulty appeared to be due principally to the fact that in most cases there was present a mixture of organisms, some of which were capable of liquefying the entire plate in 48 hours while others required several days, or even weeks, to show the first signs of liquefaction. The action of the slower ones was, therefore, masked by that of the more rapid.

After a large number of gelatin plates had been made and it was found that irregular counts were very frequent, it was decided to abandon the method except in special instances where special information was required.

DETERMINATION OF THE NUMBER OF ORGANISMS PRODUCING GAS FROM LACTOSE IN THE PRESENCE OF BILE SALT.

At the time of plating 1 cc of each dilution was transferred to a Durham fermentation tube containing lactose bile salt medium.

These tubes were incubated for two days at 37° C., at the end of which time each dilution showing gas was recorded as positive. The fermentation tests were in every case started with the 1 to 10 dilution and carried at least one dilution higher than the plating. The denomination of the highest dilution showing positive results was reported as the number of gas-producing organisms in the sample. This is the generally accepted presumptive test for *B. coli* group.

FURTHER EXAMINATION OF THE GAS-PRODUCING ORGANISMS.

As far as time permitted, one of the higher dilutions from each sample showing gas production was plated qualitatively either on litmus lactose agar or Endo's medium. From these plates typical coli-like colonies were selected and examined to ascertain whether they conformed to the definition of *B. coli communis* as given in the 1905 Report of the American Public Health Association. For this purpose they were subjected to the following tests, morphology, Gram stain, motility, liquefaction of gelatin, coagulation of milk, production of indol from peptone solution, reduction of nitrates to nitrites, fermentation of lactose, and fermentation of dextrose. They were then tested for gas production in dulcite, sucrose, mannite, and raffinose, in order to classify them according to the scheme outlined in the 1912 Standard Methods of Water Analysis, American Public Health Association.

CULTURE MEDIA USED.

The nutrient agar, gelatin, and broth were made from fresh beef practically in accordance with the directions given in Standard Methods of Water Analysis, American Public Health Association, except that they were made in larger quantities than there specified and were cleared with egg white and filtered through paper.

The lactose bile salt medium was prepared by dissolving 10 grams of peptone, 5 grams of bile salt (commercial sodium taurocholate), and 5 grams of sodium chlorid in 1 liter of distilled water, filtering and adding 10 grams of lactose.

The sugar broths were prepared by adding 1 per cent of the sugar to neutral sugar-free nutrient broth, made from fresh beef.

The milk was fresh, separator skimmed. It was used both with and without litmus.

ANALYTICAL METHODS USED IN THE "EGG INVESTIGATION" DURING THE SUMMER OF 1912, AT OMAHA, NEBR.

Ammoniacal nitrogen.—Briefly stated, the method consisted in making the egg solution slightly alkaline with sodium carbonate, driving out the ammoniacal nitrogen with a current of air, absorb-

ing the ammonia in standard sulphuric acid, and titrating the excess of the latter with twentieth-normal ammonia solution, using congo red as indicator. For liquid egg, 50 grams were weighed into a liter suction flask, 200 cc of water were added, and the flask violently shaken until a uniform suspension was secured. There was then added in turn 100 cc of 95 per cent alcohol, to prevent foaming, 2 grams of sodium carbonate, to render the solution alkaline, and 1 gram of sodium fluorid as a preservative, the mixture being shaken after the addition of each reagent. The flask was then put in place and aspirated for five hours, using a strong air current. The latter was first drawn through a 25 per cent solution of sulphuric acid to remove ammonia, and was then delivered to the aspirating flask through a tube with several small perforations, thus affecting an excellent distribution of the air current through the egg mixture. It was then passed through a trap which caught any particles carried over mechanically or through foaming, through the absorption flask, which contained 10 cc of twentieth-normal sulphuric acid diluted with 50 cc of water, and finally through a second trap, which retained any acid carried over mechanically. Three hundred cubic centimeter Erlenmeyer flasks were used for the absorption apparatus and traps. From time to time the flask containing the egg mixture was shaken to insure complete removal of the ammonia. After the air current had passed for five hours the apparatus was disconnected, the second trap and connecting tubes were rinsed off into the absorption flask, and the excess of acid titrated with twentieth-normal ammonia solution, using congo red as an indicator. For desiccated eggs 20 grams were weighed into a liter suction flask, 230 cc of water added, and this same process followed.

Moisture.—About 3 grams of egg were weighed into a small lead dish (bottle cap), dried in a water-jacketed oven at 100° C. for one hour, placed in a vacuum oven and dried in vacuo at 70° C. for 10 hours, cooled in a desiccator, and weighed. The sample was then reheated in vacuo until constant or increased weight was noted, weighing at intervals of two hours. The lowest weight obtained was taken as the nearest approximation to the correct figure.

Ether extract.—The lead dish and dried sample from the moisture determination were cut into small pieces, placed in a Johnson extraction apparatus, extracted for 16 hours with anhydrous ether, the ether expelled on the steam bath and the fat dried at 100° C., cooled in a desiccator, and weighed.

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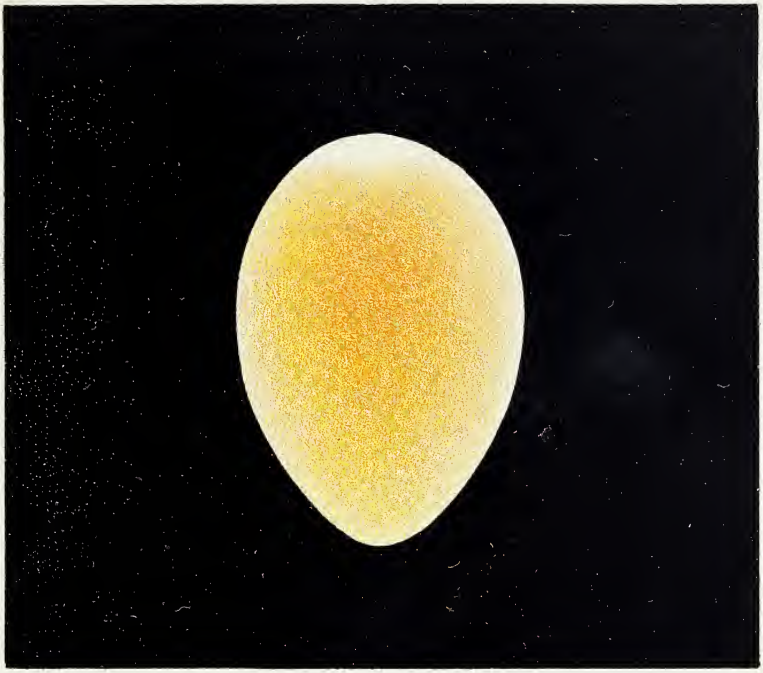
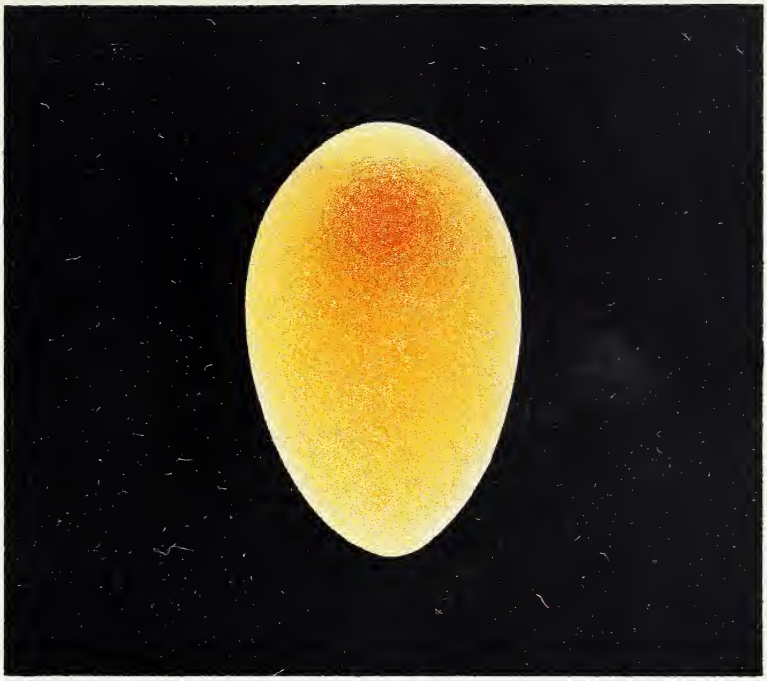


H.M.P. Betts

A FRESH EGG BEFORE THE CANDLE AND OUT OF THE SHELL



SLIGHTLY STALE EGG SHOWING EVIDENCE OF INCUBATION
BEFORE THE CANDLE AND OUT OF THE SHELL

BREUKER & KESSLER CO. PHILA

H·M·P·Betts

STALE EGG SHOWING A SETTLED, FLATTENED YOLK AND A THIN WHITE BEFORE THE CANDLE AND OUT OF THE SHELL

BREUKER & KESSLER CO.

EGG WITH YOLK BEGINNING TO ADHERE TO SHELL
BEFORE THE CANDLE AND OUT OF THE SHELL

BREUKER & KESSLER CO. PHILA

H.M.P. Betts

EGG SHOWING "BLOOD RING"
BEFORE THE CANDLE AND OUT OF THE SHELL

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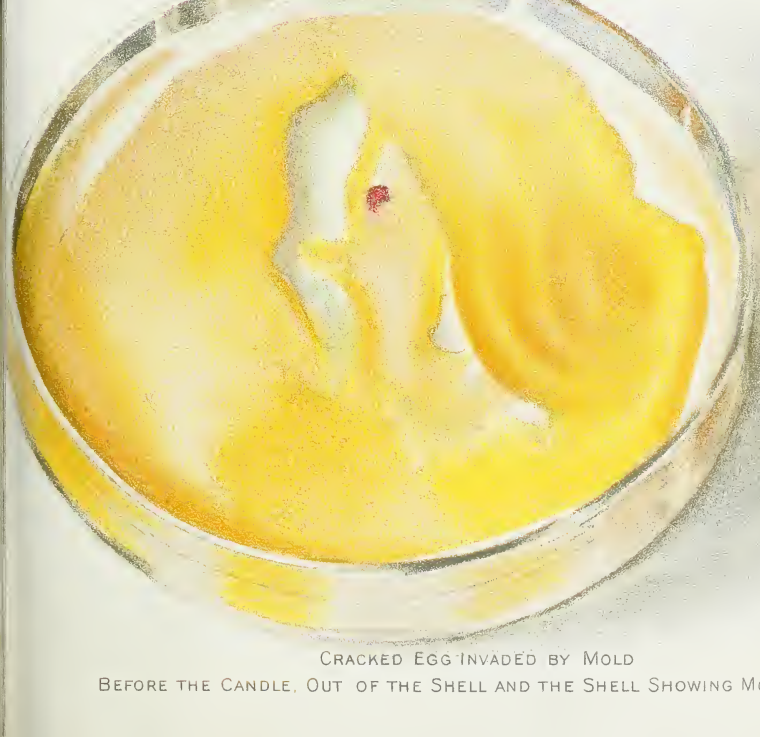

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CRACKED EGG INVADED BY MOLD

BEFORE THE CANDLE. OUT OF THE SHELL AND THE SHELL SHOWING MOLD INSIDE

H.M.P. Betts

WHITE ROT OR ADDLED EGG
BEFORE THE CANDLE AND OUT OF THE SHELL

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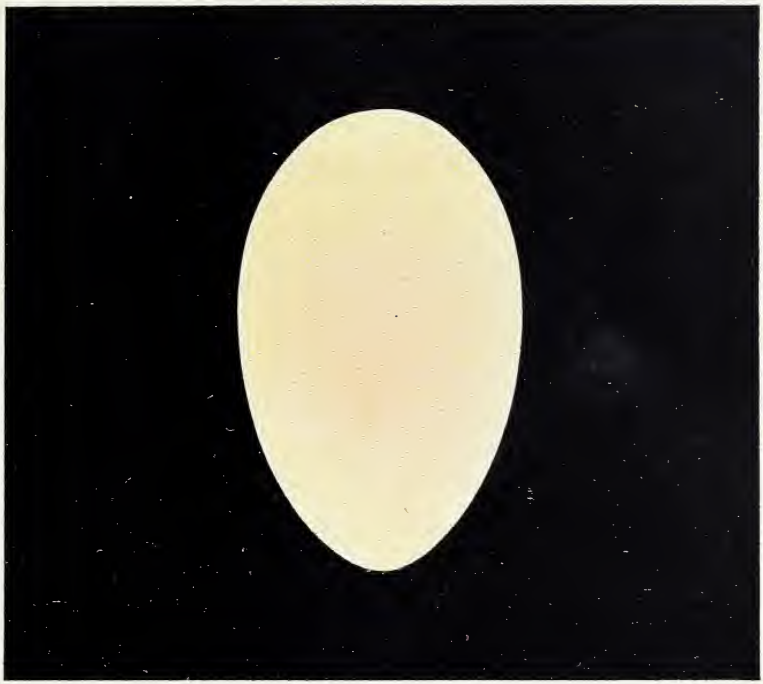

EGG WITH A GREEN WHITE
BEFORE THE CANDLE AND OUT OF THE SHELL