Issued October 5, 1909.

U. S. DEPARTMENT OF AGRICULTURE,

BUREAU OF ANIMAL INDUSTRY—BULLETIN 115.

A. D. MELVIN, CHIEF OF BUREAU.

AMEMBERT CHEESE PROBLEMS IN THE UNITED STATES.

BY

CHARLES THOM, PH. D.,
Mycologist in Cheese Investigations, Dairy Division.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., July 8, 1909.

Sir: I have the honor to transmit herewith, and to recommend for publication in the bulletin series of this Bureau, a manuscript entitled "Camembert Cheese Problems in the United States," by Dr. Charles Thom, mycologist in cheese investigations of the Dairy Division of this Bureau. The paper describes the latest phase of the cooperative work in connection with European varieties of soft cheese which has been in progress for the past five years between the Dairy Division and the Storrs (Conn.) Agricultural Experiment Station.

The greater part of the work mentioned has related to the manufacture of the Camembert type of cheese in the United States, this being a well-known variety and one that has already been produced on a commercial scale with varying success in some of our Northeastern States, besides being extensively imported. Efforts to establish the industry in the United States have not been wholly successful, and it appears from Doctor Thom's investigations that this is due to the fact that climatic conditions are unfavorable during the greater part of the year in most of the regions where factories have been located. Of a number of American cities studied, San Francisco alone was found to have climatic conditions approaching closely those of the Camembert district of France. It is believed, however, that the climatic disadvantages in sections where they exist can be overcome by constructing factories in such a manner as to provide proper control of temperature, humidity, and ventilation.

Doctor Thom has made a very thorough investigation of the peculiar problems incident to the manufacture of Camembert in this country, and it is hoped that the results of his work, herein described, will be of value and assistance in establishing the industry upon a more successful and permanent basis.

A list of the publications previously issued by this Bureau upon the subject of Camembert cheese will be found at the end of the bulletin.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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CAMEMBERT CHEESE PROBLEMS IN THE UNITED STATES.

SUMMARY.

The following summary presents the main features of the processes and problems involved in the manufacture of Camembert cheese and gives references to pages where these subjects are discussed more in detail.

EQUIPMENT AND CONDITIONS.

The descriptions of equipment and conditions desired in making Camembert cheese are based upon the practice of the factories in France and in the United States. Pages 10–15.

MAKING PROCESS.

Making-room temperature, 60 to 75° F., about 68° preferred; keep temperature as uniform as possible. Page 14.

Air of room, moist to wet. Page 14.

Milk, whole or very slightly skimmed (0.5 per cent), not over eighteen hours old. Pages 16–17.

Starter, any standard form, 0.5 to 1 per cent, twelve to eighteen hours ripening (overnight) below 57° F. Pages 18–21.

Acidity at renneting, 0.20 to 0.23 per cent (phenolphthalein). Pages 18–21.

Temperature of renneting, 86° F., limits, 84 to 90° F.

Rennet, 3 to 5 ounces per 1,000 pounds (10 to 15 cubic centimeters per 100 pounds). Page 22.

Curdling time, one and one-fourth to one and one-half hours or longer. Page 22.

Cutting curd, not advised.

Dipping, uniform distribution of curd into hoops. Page 23.

Draining, till next morning without turning.

Inoculation with molds, not necessary except when establishing factories. Page 26.

Turning, early second morning.

Salting, when firm enough to handle, usually eighteen to twenty-four hours after dipping. Several forms of manipulation used. Page 24.

Draining after salting, in making room, twenty-four to forty-eight hours. Page 25.

Cheese ready for ripening, contains 57 to 60 per cent water; when fully ripe, 47 to 50 per cent water. Cheese outside such limits calls for extra care in handling. Pages 31–32.

RIPENING PROCESS.

Conditions in ripening rooms.—(1) Temperature, 52 to 58° F. recommended. Lower temperature lengthens the process; higher temperature shortens it and hastens decay. Page 36.

(2) Relative humidity, limits about 83 to 90 or 92 per cent. Optimum depends upon temperature selected and water content of cheeses. For cheeses evenly drained and fairly firm at beginning of ripening (perhaps 57 to 59 per cent water) probably the optimum would be 86 to 88 per cent relative humidity at 52 to 54° F. Pages 37–38.

First two weeks.—Cheeses are kept upon coarse matting (clayons). Conditions should be controlled to produce a moderately thin rind showing well distributed but not heavy areas of mold interspersed with patches beginning to show reddish slime. Relative humidity must be held high enough to permit the slime to begin to show with the mold, but not so high as to prevent the appearance of the mold. Cheeses will lose probably about 3 to 6 per cent of water in this time, according to handling. Traces of softening under the rind show at the end of two weeks. Cheeses must then be removed to smooth boards or wrapped and boxed. Pages 46–47.

Third week.—Slime areas increase without other changes in appearance. Softening progresses rapidly. The rate of change depends on the temperature and the percentage of water still present. Enough evaporation must be allowed to bring the softened protein to the consistency desired (commonly 50 to 51 per cent of water at the end of the time). The progress of this change can be constantly determined by feeling the cheeses. Ripening of the proper texture and flavor must be well begun and the water content lowered to a safe percentage before cheeses can leave the factory with assurance of success in their further handling. Page 47.

Further handling.—According to the market demand, cheeses may be boxed and their further ripening completed in the cellars or in storage in the dealers' hands. The ripening should not be complete before the end of the fourth week and may often desirably be lengthened considerably beyond that time. The progress sought can be controlled to a large degree by controlling the temperature of the storage room, or ripening cellar, if one is used. If cheeses have the proper consistency at the end of the third week, proper care alone should assure good results in the further ripening. This responsibility falls upon the dealer or consumer. Pages 48–49.

Gassy curd.—The making process of Camembert subjects it to greater risks from the development of gassy curd than most other cheeses. During three successive years this trouble has been much greater during December, January, February, and March than the rest of the season. A seasonal prevalence of the gas-producing acid organism, *Bacillus lactis aerogenes*, is indicated for these months or parts of them. The introduction of 0.5 per cent, or slightly more, pure starter with ripening over night at 50 to 57° F. has produced sufficient ripening to reduce gas formation to a minimum, without raising the acidity test (phenolphthalein) above 0.22 to 0.23 per cent. Pages 19–21.

Changes in composition during ripening.—The changes in composition during the ripening period are the neutralization or destruction of acidity, the softening of the cheese due to proteolysis of the casein, and the lowering of the water content about 10 per cent. The fat is little affected. The activity of the ripening agents, and consequently the rate of ripening, is found to be closely dependent upon the amount of excess of water in the fresh cheese above the water content in the ripe cheese and to the rate and conditions under which that water is evaporated. Pages 32–34.

Temperature and humidity.—The temperature and relative humidity of the air in the ripening rooms determine the rate of loss of water in the ripening of the cheese. The temperature limits recommended are 52 to 58° F. The relative humidity indicated varied from 84 to 90 per cent, or even higher.

COMPOSITION OF CAMEMBERT CHEESE.

Analyses of imported and domestic Camembert have been tabulated and discussed, to determine as closely as possible a satisfactory standard for this variety of cheese. Marked variations have been found in various brands. The analyses of cheeses selected as representing choice conditions of texture and flavor place the average of the best cheeses within approximate limits as follows: Water, 47 to 50 per cent; fat, 25 to 28 per cent; protein, 18 to 21 per cent. Variations outside these limits are common, but seem to involve more risks of defects than those within these limits. Pages 15–16.

CLIMATIC DIFFICULTIES IN THE UNITED STATES.

Tabulation and comparison of mean temperatures and mean relative humidities for cities in northern France and certain American cities in dairy regions show that in America mean temperatures are either too high or too low for Camembert cheese ripening, except during portions of September, October, and November. In the same cities the mean relative humidity remains too low in nearly every month of the year for ripening this kind of cheese. San Francisco alone of the American cities studied shows conditions closely similar to those in northern France. Pages 39–44.

Ripening rooms built for climatic conditions found in France have failed to give success in America. Either domestic manufacture of Camembert must be abandoned in most sections or the construction of the rooms for cheese ripening must be so modified as to obtain the conditions desired. Pages 27–31.

Factories to succeed in the Eastern States must provide control of temperature and relative humidity within closer limits than those obtainable with the French plans hitherto used. This may be obtained by better insulation of the rooms already built or by the construction of new rooms which may be partly or entirely below the surface of the ground. In either case the building must provide means for thorough but controlled ventilation sufficient to carry off moisture as fast as required. Pages 45–46.

FACTORY AND FARM PRODUCTION.

Camembert cheesemaking for the general market is a factory proposition in which production upon a large scale conduces to economy of labor and uniformity of results. A good grade of Camembert can be made and ripened upon the farm with comparatively simple and inexpensive equipment. The difficulty of making uniform cheeses is greater when working upon a small scale. Such cheesemaking can not at present be advised except for home use or for sale to a special market served directly by the producer. Pages 50–53.

INTRODUCTION.

Numerous practical and scientific problems have been encountered in attempting to establish the manufacture of Camembert cheese in the United States. Some of these, together with the practices followed in the first two years of the investigation, have been discussed in previous papers. Before and during the progress of this early work several factories undertook to produce this cheese in America. Most of these companies established plants with the object of reproducing as nearly as possible the buildings and equipment successful in France, and employed experienced cheesemakers from that country to carry on the work. At one time the product of these factories made up fully one-fourth the total amount of Camembert consumed in America. The production and sale of this cheese was, however, attended by uncertainties as to market and by numerous losses in the factory. Some of these difficulties were readily recognized, but in many cases even the experienced maker failed without being able to find the reasons for his losses. So much difficulty and discouragement have attended these enterprises that some of them have been entirely abandoned, and the product from all has been greatly reduced.

In continuing the investigation, experimental work at Storrs has been supplemented by a study of the problems of the market (see Circular 145, Bureau of Animal Industry), and by visits to all the factories carrying on this work.

This paper is a report of progress upon the studies of the problems which have come up in this work, together with modifications of handling that will bring the processes recommended into substantial harmony with factory practice.

In spite of the failures which have occurred in the past, there is good reason to believe that a readjustment of methods to conditions will eventually bring permanent success. Without such readjustment, the transplanting of the Camembert industry to our Eastern States has so far disappointed the investors. It can not, however, be claimed that all the difficulties have been overcome in the practices discussed in this paper, but much progress has been made toward practical working success and toward correct interpretation of the causes for past failures and losses.

FACTORY EQUIPMENT.

The equipment of a Camembert cheese factory comprises most of the apparatus and utensils common to all creamery work. A room for receiving and weighing the milk, apparatus for testing the amount of fat in milk, steam for heating and sterilizing purposes, etc., such as are found in any up-to-date dairy, are essential. In other words, all the usual contrivances that facilitate the rapid and sanitary handling of milk in large quantities must be provided.

All of the rooms in the factory should be constructed with a view to the maintenance of strict cleanliness. In the room in which the milk is delivered and also in the cheesemaking room the floors must be flushed daily with water to remove any milk or curd that otherwise would form a breeding place for germs or insects. To this end the floors should be of cement and should slope toward one or more drainpipes. The walls also should be of some material that can be kept clean, and should be painted or whitewashed from time to time. The cheesemaking room, as well as all the other rooms where the cheese is handled, must be protected from flies and other insects. Unless great precautions are taken, swarms of flies will invade the room and deposit their eggs on the cheese, and a few days later, in the ripening room, these eggs will hatch out into maggots. All the windows must therefore be screened with wire netting of fine mesh, and every effort made to prevent the entrance of flies when the doors are opened.

THE RECEIVING ROOM.

The room for receiving the milk requires the same equipment as in ordinary dairy work. A vat with capacity sufficient for the mixing, heating, and ripening of all the milk used each day is usually provided. There may be either a single vat or several, but the use of the larger vat insures the thorough mixing of the whole milk supply, and hence a more uniform composition of the whole lot from day to day than would be obtained from the use of several vats. Aside from the desirability of mixing the milk for uniformity, a small receiving vat from which the milk runs directly through a milk heater to the curdling cans is equally efficient.

THE CHEESEMAKING ROOM.

The floor of a cheesemaking room is usually cement, either upon or slightly below the surface of the ground. The room should be well lighted. Double sashes are used to protect the room from abrupt changes of temperature, and usually two or more of the windows are well screened and arranged to open conveniently for ventilation when desired. To avoid the accumulation of dirt the inside sash should be hinged and close up flush with the wall surface, leaving no ledges to gather filth.

Figure 1 illustrates the cheesemaking room and its equipment in a Camembert factory in the United States.

EQUIPMENT OF CHEESEMAKING ROOM.

Aside from the general equipment for all creamery work, such as steam, water, and hose, the special equipment and apparatus for Camembert cheesemaking will be briefly described.

Tables.—Enough table surfa e is demanded to accommodate the cheeses to be made in two days. These tables ("tables à mouler") are 36 to 42 inches wide, fastened in pairs to the opposite sides of two vertical pillars about 32 inches above the floor. A raised edge on each side prevents whey from running from the table to the floor. The tables slope toward the pillars to which they are fastened and toward one end, so that a single gutter connecting their ends carries off the whey from all the tables. They are constructed of wood with smooth surface, sometimes of wood covered with galvanized iron. It is best not to have the wood protected by metal or any heat-conducting material. The temperature of the curd being several degrees

FIG. 1.—Camembert cheesemaking room in American factory, showing arrangement of tables, aisles, curdling cans, and milk-distributing pipes.

above that of the room, the curd cools more or less rapidly while draining, and the rate of loss of heat is increased when the curd is in contact with a cold sheet of metal. This retards draining and produces an uneven texture on account of the different rate of cooling of the top and bottom of the cheese.

In most factories, directly above the draining tables and fastened to the pillars in the same way, 3 feet above the tables, are shelves of about the width of the draining table. They are used for draining the cheese during the second and third days, when space is needed. These shelves are not used except when space is urgently needed, and often not at all.

Aisles.—The aisles between the tables should be wide enough for the maker to work comfortably. Sometimes only 26 inches are allowed, but 32 to 36 inches would be more comfortable working room.

Draining mats.—These are imported from France. The matting is made in strips like cloth of different widths and is bought by the roll. It is composed of delicate wood strips held together by thread. The matting purchased should be exactly as wide as the draining tables. It is cut into lengths convenient for handling and washing. These may be the full length of the tables unless the tables are very long.

Hoops or forms.—The number of hoops provided should be twice the number of cheeses to be made each day. The hoops used vary slightly (perhaps a quarter of an inch) in diameter in different factories. They are preferably made of heavy tin with edges turned and soldered. The hoops used in factories visited have been 5 inches high and 4⅝ inches in diameter. The diameter used by different makers often differs one-eighth of an inch from this average. Each hoop is perforated with three rows of holes one-twelfth of an inch in diameter and about 2 inches apart in the row. Although hoops 5 inches high are regularly used, it is often necessary to fill them up after the curd has been dipped some time. When this is found to be the case, it might be desirable to make the hoops half an inch higher. Some have used also a low hoop for draining on the second day. Its use is not general and is not recommended.

Disks.—In some factories heavy tin disks are provided. These exactly fit the hoops and are used as weights to produce a smooth upper surface upon the cheeses. These have not been used much in this country and did not give satisfaction when tried in our work. In some factories a handle carrying a rubber sucking disk is provided to remove these disks.

Dippers.—The curd is transferred from curdling cans to hoops by means of long-handled dippers which are small enough for the bowl of the dipper to be lowered into the hoops.

Curdling cans.—Curdling cans (shown in fig. 1) are made to hold about 200 pounds of milk each. These cans are made of heavy metal and taper from about 12 inches in diameter at the bottom to 20 to 24 inches at the top. Handles at the top make them more convenient to move.

Trucks.—For each one or two makers dipping cheese a truck must be provided. This consists essentially of a round base with a rim perhaps half an inch high, into which the curdling cans fit readily. Under this base rollers provide easy motion in any desired direction. The height of the truck plus the height of the curdling can should bring the edge of the can very nearly to the top of the hoops when they are arranged upon the draining table. This will minimize the labor of dipping as described later. The trucks are shown in figure 1.

Curdling shelf.—A shelf conveniently placed should be just high enough from the floor to allow the curdling cans to slide readily upon the trucks. The tables are usually placed with one end toward the windows, the aisles between and across the inner end, with curdling cans arranged on their shelf along the inner wall of the room. Arrangement is, however, a matter of convenience. Instead of a wooden shelf, sections of the concrete floor along the wall are often simply raised above the main level of the floor high enough to move the cans easily to the trucks.

Salting boards.—Boards or trays are provided for handling freshly salted cheeses while they remain in the making room. These are made from ¾-inch smooth matched lumber, held together by cleats to make the boards or trays about 24 by 30 inches—large enough to carry 30 cheeses.

Other apparatus has sometimes been used or recommended for the cheesemaking room. Vats, for example, can be used instead of curdling cans, but they entail a larger initial cost, to which must be added the constant extra labor of lifting curd by dipperfuls from the vat across the aisle to the hoops. This extra labor is in itself prohibitive of the use of vats. The use of corrugated draining boards upon the tables is added labor and expense, without compensating advantage. The apparatus described here has shown its economy by its general acceptance in cheese factories.

CONDITIONS REQUIRED.

Temperature.—The limits are 60° to 75° F., the preferred temperature being 68° F. These limits are recommended by students of French practice, and experimental work has given the same results. If the temperature is allowed to go below 60° F. the drainage of the cheese is delayed or even entirely interrupted. If the room is too warm the danger of developing gassy cheeses is much greater. Bacteriological studies by Conn, Esten, Stocking, and others have fixed 70° F. as a condition under which the typical lactic bacteria work more rapidly than gas-producing types; whereas from 70° to 98°—as the temperature approaches blood heat—the gas-producing species gradually increase in activity until they reach dominance. At the high temperatures the rate of separation of whey increases also. It has been found desirable to hold the making room slightly under rather than over 70° F., if there is a preference within the limits given.

Humidity.—The room should be kept moist—not fully saturated, but so moist that surface evaporation is slow. Rapid evaporation causes the curd to adhere to the hoops and makes badly shaped cheeses. Cheeses tend to dry out and shrink quickly in dry air. The upper face of a cheese will shrink in diameter often half an inch while draining in a dry room. Rapid evaporation produces a thin, hard rind over wet curd instead of a gradual and uniform reduction of water content throughout the whole cheese. To obtain the proper water content a cheese must drain out, not dry out.

Ventilation.—The actual rate of ventilation in the making room appears to matter very little so long as the air is kept pure. In our climate the changes of temperature are more rapid and the air averages much dryer than in Normandy. Ventilation must, therefore, be much more closely restricted to avoid dryness than in French factories. The cheesemaking area in the United States is also much higher above sea level, with prevailing winds blowing over large land areas. All these things contribute to the need of greater restriction of ventilation in the making room than appears in French factories.

Milk.—Good, clean milk, not over eighteen to twenty hours old, forms the best basis for work. Milk older than this, if well cooled and cared for, may be used; but the danger of gassy fermentations increases so greatly that our experience amply justifies the French practice of using the fresh milk of the morning mixed with the well cooled milk of the night before.

STANDARDS OF COMPOSITION OF CHEESE AND MILK.

CHEESE.

The practice of removing a small part of the fat from the milk used in making Camembert cheese is admitted to be very common in France. The amount of such skimming varies with the maker, the richness of the milk, and the season. The several brands of this cheese appearing in the American market have been purchased and analyzed from time to time during the past five years, to establish, if possible, standards for comparison. The following table presents fairly representative analyses for cheese appearing upon the market in fall and winter:

TABLE 1.—*Analyses of Camembert cheese in American markets.*

Sample No.	Analyst.	Water.	Fat.	Protein.	Proportion of fat to protein.
		Per cent.	*Per cent.*	*Per cent.*	
1	Dox	47.50	26.30	21.80	1:0.82
2	....do	45.59	27.71	21.10	1: .77
3	....do	46.36	27.78	21.21	1: .76
4	Edmond	48.41	27.01	19.36	1: .71
5	....do	48.79	26.72	18.75	1: .71
6	....do	43.08	32.13	21.27	1: .66
7	....do	41.25	31.09	19.69	1: .60
8	....do	50.59	26.30	18.83	1: .71
9	Dox	47.03	26.67	20.32	1: .73
10	Edmond	51.41	23.01	16.83	1: .73
11	....do	51.23	25.68	17.61	1: .68
12	....do	47.69	27.32	19.05	1: .69
	Average of 12 analyses	47.91	27.33	19.66	1: .71

Cheese No. 4 in the table reached the analyst in almost perfect condition, both as to texture and flavor; it may be regarded as giving nearly a typical analysis, therefore, for the best Camembert. Nos. 8 and 9 were made in America; all of the others were imported.

Taking the relation of fat and casein given by Van Slyke,[a] cheeses Nos. 6 and 7 represent approximately milk testing 4 per cent fat. This allows a casein loss of 0.1 per cent and a fat loss of 0.2 to 0.25 per cent. Inspection of the ratio of fat to protein in every other case shows evidence of the removal of a small part of the fat. Some of these cheeses were manifestly low in water content from exposure in the market and consequent evaporation. The same is very evidently true of certain of the analyses given by Von Klenze and by Doane and Lawson.[b]

The percentage of water as shown in this table was from 43+ to 50+, but in those cheeses analyzed in the best condition the percentage has been found to vary from 46 to 50, or slightly more; probably 48 per cent, with a variation of 2 per cent either way, would include most of the better cheeses as they reach the American market. It must be admitted, however, that very many good cheeses found in the open market show signs of shrinkage, which indicates that they had contained 52 to 55 per cent of water, or even more, at the time of shipment. Fifty per cent may therefore be considered a fair average for partially ripe cheeses when they go to market. The further ripening commonly reduces this 2 and often 3 to 4 per cent without serious loss of quality.

In fat content all the cheeses in the table excepting three (Nos. 6, 7, and 10) varied little more than 2 per cent—that is, from 26 to 28 per cent. Nos. 6 and 7 were especially high in fat and correspondingly low in water, and appeared to be the output of the same factory. The column marked "Protein" shows almost as narrow a variation on the average cheese, running from 19 to 21 per cent. Analysis of the richer grades of American milk indicate that at least 0.5 per cent of fat may be removed from milk testing 4.25 per cent or over, and still leave the ratio of fat to protein as high as found in good imported cheeses. In very rich milk the fat figure would yet be relatively too high in many cases.

STANDARD MILK FOR CAMEMBERT.

The analyses given, supplemented by those of cheeses made from milk standardized at from 3 to 6 per cent fat content, show that

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[a] Van Slyke, L. L., and Publow, C. A. The Science and Practice of Cheese-making, p. 233.

[b] Doane, C. F., and Lawson, H. W. Varieties of Cheese. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 105.

Camembert cheese requires good milk, but not milk excessively rich in fat. The closest correspondence with the composition of the best imported cheese was obtained by using Jersey milk standardized to 3.8 per cent fat after the removal of 0.5 per cent of the fat—a percentage still rather above that of average factory milk. The ratio of fat to protein in the average analysis (1:0.71) indicates the removal of some fat [a] as the usual condition. Although certain factories manifestly use whole milk, in most of them a moderate skimming is always practiced. There appears to be good reason to believe, as claimed by Roger, that the ratio of fat to protein shown by the average analysis of Camembert produces a cheese of better texture and more satisfactory flavor than when the fat is greatly increased, as is the case with unmixed Jersey milk, for example.

Since, however, there is no profit in skimming, it should be practiced as little as possible. For profitable results cheeses should be made to carry all the fat they will without causing injury to texture and flavor. If we calculate Camembert at approximately 50 per cent water, every pound of milk solids (fat and casein) carries with it an equal amount of water in making up the yield of cheese. Milk fat, therefore, sells in the same markets more profitably as Camembert cheese than as butter. The removal of more than 0.5 per cent of fat is probably not warranted with ordinary factory milk. In some cases a less amount would be better, but some fat should ordinarily be removed from all milk to obtain the proper proportions of fat and casein in this cheese.

RELATION OF FAT AND WATER TO TEXTURE.

In studies of cheeses made from the same milk standardized to high and low fat content it is uniformly found that under conditions otherwise the same the milk low in fat produces cheeses higher in water content. In Camembert, therefore, as in the hard cheeses, to obtain the same texture from milk partly skimmed as from rich whole milk the loss of fat is partly, at least, replaced by higher percentages of water.

[a] Van Slyke and Publow (loc. cit., p. 165) give the ratio of fat to casein in the milk of different breeds as varying from 1:0.67 for Holstein-Friesian to 1:0.52 for the highest grade of Jersey milk. In no case do they find factory milk to give a higher ratio than 1:0.67 or 0.68. The experiments here cited were made with milk originally high in fat. The figures given by these authors have been confirmed by work done at the Storrs station and by unpublished figures collected by the Dairy Division from a large number of factories.

STARTERS AND ACIDITY.

Some makers prefer not to use starters. Our experience has always justified the use of starters, the result being a reduction of losses from gas and the production of a better draining cheese.

The so-called "natural" starters, when entirely free from gas or taint, are always good. Many factories use no other kind. Buttermilk when in good condition produces acidity rapidly and gives a product uniform in flavor and texture. It is subject to rapid deterioration, however, and if used must be watched carefully for gassy fermentation.

The commercial starters as a rule produce excellent final acidity and seem to result in cheeses of stronger flavor. It has been generally more difficult, nevertheless, to obtain uniform results with them. Apparently starters made from these cultures have varied considerably in the rate and intensity of their activity; hence cheeses made from day to day differed more than those made with a natural starter. With proper care commercial starters probably give the best results on an average.

Acidity at renneting time.[a]—From 0.20 to 0.23 per cent has given our best results. If the acidity is higher than 0.25 the curd is not so smooth—that is, when broken between the fingers it feels grainy or mealy, "rough." If acid is too low—0.16 to 0.18 per cent—it requires more rennet, longer curdling time, and longer draining time, but produces a good curd in our experiments. Since, however, milk usually enters the factory with some acidity, it is hardly practicable to plan to work at an acidity lower than 0.20 per cent. The practice has therefore been adjusted to such milk as is usually obtainable. On the same grounds, with equal reason, milk with higher acidity than 0.20 per cent when received is not desirable, and cleaner and fresher milk should be insisted upon. Milk with excessive acidity when received quite often develops gas or other fermentation (yeast, bad odors, etc.), and this indicates that it is already old or dirty, or both. Milk known to be gassy, or in which conditions point to gas formation, should be rejected.

The addition of acid or strong starters in quantity sufficient to bring clean, fresh milk at once to the acidity desired has been tried, but without satisfactory results. Success in making Camembert cheese calls for the development of acidity by the development of the typical lactic organisms rapidly enough to prevent unfavorable fermentation. The bacteria added in very sour starters seem to require

[a] The percentages of acidity given in this paper are obtained by titration of 17.6 c. c. of milk to phenolphthalein with n/10 sodium hydroxid. The number of cubic centimeters of alkali required divided by 20 gives the percentage of acidity calculated as lactic acid.

some time to adjust themselves to growth in fresh milk. If in this same time the milk is curdled and partially drained of whey, which carries out with it a large part of the milk sugar, the souring process does not seem to go on normally. We seek by the addition of a starter to give the organisms desired a thorough distribution through the milk and to produce very quickly a preponderance at least of numbers over the undesirable species. In these experiments the advantage seemed to have been thrown away when rennet was added without interposing a short ripening period. Whether the failure in such a case is due to incomplete distribution of the organisms or to the changed composition of the milk due to curdling and draining is not determined.

The presence of the organisms producing gassy curd is very common in Camembert cheese. Many of the market cheeses, both domestic and imported, show more or less gas when cut. Although good cheeses often show traces of gas, the presence of many gas holes in Camembert lowers its quality. A careful study of the prevalence of gas formation and its control seems very necessary to success.

THE PREVALENCE OF GASSY CURD AT CERTAIN SEASONS.

For three successive winters—1907, 1908, and 1909—gassy fermentations during January, February, and March have been found and shown to be due to the prevalence of the coli-aerogenes group of bacteria (identified by Prof. W. M. Esten) in the milk during these months. Incubation experiments with samples of milk during portions of the winter of 1909 failed to develop normal smooth curd in any large percentage of samples studied. Experimental manufacture of Camembert cheese during the months mentioned for the three years was seriously interfered with by the constant appearance of these organisms. The coli-aerogenes bacteria produce gas holes of varying size in Camembert curd and give to the newly made cheese an offensive odor. In these same months of each year the normal activity of the typical lactic species (*Bacillus lactis acidi*), which usually reduces or entirely eliminates the gassy fermentation, failed to develop in untreated milk. Examination of the product of certain factories in New York State showed the same conditions to be prevalent there during the same seasons. Imported cheeses purchased for examination commonly showed more or less of the same trouble. There seems, therefore, to have been a periodical and perhaps a seasonal failure in the activity of the normal souring organism, even when present.

In general, this has resulted in the dominance of the gas-producing type during the first twenty-four hours at least; that is, during the draining period of this kind of cheese. This is long enough to injure the texture and odor of the newly made cheese. Such gassy cheese often settles together in the succeeding days so that the gas holes are closed and temporarily nearly obliterated. In such cases the typical lactic forms have probably become dominant as the acidity of the cheese increased. After the milk sugar is used up the activity of both forms ceases, or nearly so. In the later stages of ripening, however, after the cheese has begun to soften, the gas organisms seem to resume activity and render the ripe cheese noticeably gassy and often seriously bad-flavored.

During the gassy period the methods which produce good drainage and smooth-textured cheese during the remainder of the year have failed to be effective, either in our experimental work or in factory practice, as judged by the cheeses seen in many cases.

A series of experiments was made to devise means of eliminating or controlling the gassy conditions. Some of these are tabulated as follows:

TABLE 2.—*Results of starter experiments by C. J. Grant.*

Experiment No.	Starter.	Acidity of milk and starter.	Hours ripened.	Final acidity.	Temperature— At beginning.	Temperature— At end.	Results.
	Per cent.	*Per cent.*		*Per cent.*	*°F.*	*°F.*	
1830....	0.0	....	0	0.17	....	....	Very gassy.
1831....	.0	....	(a)	.18	Below 60.	....	Do.
1834....	4.0	0.225	1⅚	.255	86	....	No gas.
1835....	10.0	.25	1⅚	.30	86	....	Do.
1836....	1.8	.19	24	.31	b 66	....	Do.
1837....	5.6	.225	24	.44	b 66	....	Do.
1840....	.1	.18	24	.20	50	....	Very little gas.
1841....	.3	.18	27½	.215	50	....	Do.
1842....	.1	....	24	.25	60	60	Slightly gassy.
1843....	.3	....	24	.27	60	60	More than 1842.
1867....	2.0	....	24	.225	52	....	Trace of gas.
1870....	1.0	.18	24	.245	58	58	No gas.
1872....	1.0	.185	24	.23	58	58	Trace only of gas.
1875....	.5	....	24	.275	60	58	Do.
2356 c ..	1.0	.18	16	.18	44	50	No gas.
2358....	1.0	.18	16	.21	51	54	Do.
2360....	1.0	.18	16	.215	43	54	Do.
2362....	1.0	.18	16	.20	42	53	Do.
2364....	1.0	.18	16	.20	45	54	Do.

[a] Stood in refrigerator forty-eight hours.
[b] Acidity developed very rapidly in five hours. Put in refrigerator the remaining time.
[c] The last five experiments were made to show the relation of temperature to the production of acidity. The gassy season was already past.

Our work indicates that much more care should be given to the production of a starter in these cold months. Repeated preparation of pasteurized milk by methods satisfactory at other seasons showed traces of gas after inoculation with cultures and incubation. When, however, the skim milk used was boiled no difficulty was found in obtaining normal souring. As shown in the table, the starter was added in amounts varying from 0.5 to 10 per cent, and the milk was ripened for various periods after the addition of the starter.

In these experiments it was readily shown that the addition of 3 per cent or more of strong, active starter would reduce the gas formation to a negligible amount if a comparatively short ripening period were used. In many cases, however, the acid added in the starter, together with that developed in ripening, affected the texture of the cheese too greatly. Milk titrating from 0.24 to 0.25 per cent acidity nearly always produces a rough or mealy curd. It is difficult to employ the larger percentages of starter, because they tend to raise the acidity too greatly. Other experiments have shown that a smaller amount of starter (0.5 per cent, or sometimes less) acting for a longer period will produce what may be called a protective ripening; that is, inhibit gas without too great a rise in the titration figure. An experienced factory manager has said that he regards 0.20 per cent acid by titration as a conservative limit to ripening. This figure is, in our experiments, too low to prevent gas formation during the winter months. Examination of cheeses from the same manager's factory for successive seasons showed that his work also suffered from gas during each winter.

As noted above, the same trouble has been seen in varying degrees in a large proportion of the domestic and much of the imported cheese during the winter months. When gassy troubles occur there appears, therefore, good reason for recommending that the acidity at renneting time should be raised to about 0.23 per cent. Long series of experiments indicate that milk can be handled at this acidity without injuring the texture of the resulting curd.

AMOUNT OF STARTER NECESSARY FOR RIPENING MILK.

The length of the ripening period desirable, as well as the amount of starter, must depend upon the conditions. The same result can be reached in different ways. If milk well cooled and free from taint is received during the day and kept over night, ripening may be controlled by a minimum amount of starter (0.5 per cent or even less, perhaps) added at night to milk kept below 57° F. If the temperature goes higher, too high acidity may be expected. The same good result has been obtained by adding about 3 per cent of good starter when the milk is heated for cheesemaking and letting it ripen at 85 degrees until it has developed acidity to from 0.22 to 0.23 per cent, but in this case it must be watched to avoid too high acidity. In using starters it is quite generally agreed that a fresh starter already quite sour to taste but not curdled is preferable to the same starter after curdling. The organisms in the sour but not curdled starter appear to adjust themselves more readily to the fresh milk and to produce acidity more quickly.

DETAILS OF CHEESEMAKING.

Temperature.—The mixed milk is ordinarily heated to 85 or 86° F. The limits of satisfactory work are probably from 84 to 90° F. If color is to be added, this should be done before the milk leaves the mixing vat.

Setting and rennet.—When heated, the milk is distributed into curdling cans. In factories the milk is often piped from the vats through tin or tin-lined pipes running above the row of cans, with a cock opposite each can. Special forms of apparatus are a convenience but not necessary.

The milk is now ready to "set." For this purpose any standard form of rennet may be used. Rather more rennet is desirable than for American Cheddar cheese. Calculated on a basis of 100 pounds of milk, from 10 to 15 cubic centimeters of commercial liquid rennet (3 to 5 ounces per 1,000 pounds) may be required to obtain the proper texture of curd, according to the conditions of work. This calculation assumes the use of good clean milk not over eighteen hours old, testing when received not more than from 0.16 to 0.18 per cent acid.

Considerable disagreement is found in the recommendations as to the amount of rennet, the temperature to use, the acidity, and the length of curdling time desirable for Camembert. In experimental work different practices have been made to yield cheeses so closely alike as to baffle the description of their differences. In general, comparatively large amounts of rennet have given firmer curds and produced better textured cheeses than when minimum amounts were used. Such cheeses drain more rapidly at first, but retain more water when drainage finally ceases, than those made with the smallest amount of rennet which will permit working. The smaller quantity of rennet produces soft curd which drains more slowly, but ultimately drains lower than the other and makes hard, dry cheeses. The strength of the rennet, the acidity and composition of the milk, and the local conditions are variable factors. The cheesemaker must have in mind the ideal condition of his curd and adjust his own practice to approximate that ideal.

The directions given here do not attempt to settle disputed questions about rennet and its effects. They do, however, represent accepted practices which have also given satisfactory results in experimental work.

Curdling time.—Curd should be ready to "dip" in from one and one-fourth to one and one-half hours; some prefer even a longer time. This will be indicated by the curd beginning to "sweat," shown by the appearance of drops of water (whey) scattered over the surface of the mass of curd. These drops soon form into a thin sheet of whey upon the surface. This whey if tested for acidity as it separates usually tests from 0.02 to 0.05 per cent less than the milk at setting time. The curd is now ready to "dip," and should be smooth-textured and quite firm. Cans of curd should not stand long after they are ready to dip. If curd stands a long time in the whey it may become tough or sour, or may cool to a temperature which seriously delays draining, according to conditions. If large amounts of milk are to be handled, the cans should be renneted or set in series so that they become ready to dip as needed.

Cutting the curd.—Some makers cut the curd slightly. In cutting they use a curd knife designed to make circular cuts in the mass. Although such curd drains more rapidly, very little advantage can be claimed for cutting curd at all if working conditions are what they should be.[a] In most experiments the advantages in texture, flavor, and handling have favored curd handled without cutting, and this is the practice most generally observed in the best factories.

Arrangement of the hoops.—While milk is curdling the matting is spread upon the draining table, and the hoops are arranged upon the matting as closely as possible. The whole should then be thoroughly wet with warm water so that table and matting shall be wet when dipping begins. If the matting is not wet the curd sticks to it and causes trouble and loss from breaking the cheeses when they are turned the next day.

Dipping.—When a can of curd is ready to dip, the truck is brought into position beside the shelf, and the can gently swung upon it. The truck is then pushed into the aisle between the tables so that the edge of the can comes as close as possible to the tops of the hoops upon the table. In dipping, each dipperful of curd is lowered into the hoop and emptied without loss of time and with as little breaking as possible. One dipperful each is put into a series of hoops, and the process repeated until each hoop contains the required amount of curd. This allows time for partial drainage between dipperfuls.

To obtain cheeses of the desired size with the regular size of hoop it is often necessary to fill up the hoops again after the curd has drained an hour or two. Some experiments indicate that the same result would be more economically reached by making the hoops about half an inch higher. French factories report that 2 liters of milk are sufficient to make a cheese of the usual size. With common factory milk in this country 5 pounds have been reported as necessary to produce the same size of cheese. It is important that the cheeses be uniform—that is, that the total amount of milk be evenly

[a] Cutting curd to hasten drainage is a recourse which sometimes aids work with too cold rooms or rooms which become cold at night. When possible the condition should be corrected in such cases as soon as possible instead of changing the practice.

distributed into the proper number of hoops. The time required to do this will vary from day to day because of variations in the condition of the curd, but this should not be permitted to affect the size of the cheeses.

Two workmen to each can of curd will insure that the whole can will be emptied so quickly that breaking and draining in the can are reduced to a minimum. When a can is emptied more slowly, some of the curd becomes broken and hardens rapidly, with a tendency to the production of uneven texture in the cheeses. Quick and careful handling produces the best results.

Draining.—In a room at approximately 68° F. proper draining will require about eighteen hours before the cheeses are solid enough to turn without breaking. In this time they should have drained to less than 2 inches in thickness—perhaps 1½ inches. When ready to turn, the cheese should have a sort of elastic softness, tenacious enough to permit turning with the hand without the removal of the hoop. This turning is usually done the first thing in the morning of the day after the cheese is made. If the room is dry, some cheeses in draining will adhere to the hoops, causing a thick edge and a "dishing" of the center, which sometimes is only half the thickness of the edge. While this is especially liable to occur in a dry room, it may also happen if the hoops are rough or rusty inside or if the holes are too large. A smooth tinned surface with very small holes seems to reduce the trouble greatly without the smallness of the holes checking the drainage.

Trimming.—Rough edges may be trimmed with a knife or an instrument designed for the purpose consisting of a round disk with sharp edges attached at the center to the end of a round handle.

After dipping, in some factories, disks of heavy tinned iron which fit the hoop closely are dropped upon all the freshly dipped cheeses. These disks are said to prevent unevenness of surfaces. They exert a slight but continuous pressure upon the curd. A sucking disk of rubber on the end of a handle is used to remove these in the morning.

Salting.—After turning, the cheeses drain for several hours upon the same mat in the place in which they were made. When solid enough to stand handling, and as the workmen have time, the cheeses are salted. Various methods are in vogue. Some cheesemakers take one or two cheeses in the hands and roll them in salt, edges and both sides at the same salting. Others carefully sprinkle salt on the upper surface and the edges at one time and salt the other surface at a second salting half a day to a day later. Many makers object to handling or rubbing the surface of the cheese while salting. In this practice the cheese is touched as little as possible and only on the edges. Others pay no attention to the details of handling. We have found little advantage in any specific form of manipulation in salting.

The salt used is usually coarse grained and thoroughly dry. When salt is applied to the surface of a cheese, water (whey) is extracted by the salt. A large part of the salt flows off in this whey and is lost. Some of it, however, diffuses into the cheese. The taste for salt in cheese differs greatly. Different makers of cheese respond to this demand by using different amounts.

The salting establishes a rind upon the fresh cheese. On this rind the molds and bacteria develop afterwards. Many theories are heard as to the relationship of salting to draining and to the growth of the ripening organisms. Proofs of particular views are difficult to obtain because the conditions under which each maker has developed his own view have never been adequately defined. Experiments show that the ripening of the cheese is closely dependent upon its water content and the ripening conditions. The balance between these conditions differs in different factories, but may still be adjusted to obtain good final ripening. No one has been able, therefore, to test all these theories.

After salting, the cheeses are placed upon salting boards, where they remain until they go to the curing room (halloir). The boards are first conveniently rested upon the draining table, with the edges next to the aisle supported by the raised edge of the table, so that the workman can grasp the edges of the board. If space is needed, the salting boards are next raised to the shelf above the draining table, where they remain for the final day of draining. In this way the draining table is cleared for cheesemaking without removing the cheeses from the room. It is possible to use the same tables on successive days for making cheese by removing cheeses to the shelves above in the morning and hurrying the salting process, but larger table space permitting half the table surface to be used for making cheese each day seems an economy of labor.

Draining after salting.—If drainage goes on properly, a cheese should be dry enough to salt eighteen hours after it has been dipped (on the morning after making), or even in less time. A cheese that is wet after eighteen hours (on the morning after making) will probably be ready to salt by the afternoon of that day. The drier cheese salted the second day should stand in the making room until the third afternoon—that is, about thirty hours after salting. If, however, the cheese is wet at eighteen hours old and salting is delayed until it is twenty-four hours old or longer, it should stand after salting at least twelve hours longer than the other—until, say, forty-two hours after salting. No absolute time for draining can be stated, but the figures given may be regarded as desirable intervals found in practice under the conditions named.

Before leaving the making room the cheese should be solid enough so that there is no tendency for the fingers to dent the edges of the cheese when picking it up.

INOCULATION WITH CAMEMBERT MOLD.

If the cheese is to be inoculated at all with the Camembert mold, this should be done just before salting. Inoculation with mold spores, however, has not been practiced in Camembert cheese factories. Once in the factory, the mold has been left to propagate itself. Examination of cultures from most widely separate sources indicates, however, that this mold is not native in America, although there is no difficulty in propagating it here. There seems to be excellent reason for introducing this mold by definite inoculation when new factories are established. Once introduced, so long as proper conditions are maintained, the mold propagates itself so well, as a rule, that inoculation of the fresh cheeses from day to day with pure cultures is probably unnecessary.

When pure cultures are found necessary it would be best to procure them from some reliable laboratory. They can, however, be prepared at home by anyone slightly familiar with the methods of culture used in bacteriology and mycology. When procured they may be used as follows:

Take a small jar with a tin cover which has been punched full of small holes (or an ordinary pepper box). Fill it half full of water, add a piece of moldy cracker or a piece of cheese with a good growth of the proper mold, and shake thoroughly. The contents of the jar are now sprinkled upon the surface of the cheeses, which are then turned and inoculated in the same manner on the other side.

Mold for inoculating.—For those desiring to prepare inoculating material the following practice is recommended: Obtain the hard, dry "water cracker" ("milk crackers" are not satisfactory). Fill quart fruit jars with these crackers and screw on the covers loosely without rubbers. Bake in an oven about two hours (in a laboratory dry sterilize at 140° C. for one hour or more). Care should be used not to burn the crackers. The spores can be transferred directly with a sterilized needle from a stock culture, which should be procured from a reliable laboratory, or they may be put first into sterile water. Each quart jar requires about 3 ounces (100 c. c.) of sterilized water to which 5 to 10 per cent of lactic or tartaric acid has been added (or the water may be boiled thoroughly in a flask plugged with cotton). After cooling, this water may have the mold spores put into it and then be poured into the jar (precautions being used to keep out contamination), when one side only of the cover is raised sufficiently. Roll the jar in the hands to wet all the crackers. When the crackers are all wet, pour off the excess water before they soften into a pasty mass. Set away at living-room temperature (70° F.). The crackers should be well covered with cottony white mold in ten days. The gray-green color of ripe spores which follows in a few days indicates that the crackers are ready for use.

THE RIPENING OF CAMEMBERT CHEESE.

In factories in France and in those established by French cheese-makers in this country the cheeses are made in a ground-floor room, as a rule, then carried to a second-floor room just above the making room. (See fig. 2.) This first ripening room is furnished with

FIG. 2.—Camembert cheese factory at Lisieux, France. The square windows are seen in the second-floor rooms which are used in the first two weeks of ripening. (From Twenty-second Annual Report, Bureau of Animal Industry.)

windows upon two sides, at least, to provide facilities for rapid ventilation. Various names are given to this room, one of the commonest of which is "halloir." It is characterized by ample provision for ventilation. In our climate, with its extremes of heat and cold, the windows have outer and inner sash, both hinged, making possible free ventilation when wanted and the control of ventilation or of heating and cooling in accordance with changes in the weather. These windows may be large and run from floor to ceiling, or may be small rectangular openings scattered over the whole side of the room. In all cases they must be closely screened to exclude the small flies which are so serious a pest in cheese work.

The humidity in these rooms, as observed, has varied from complete saturation to a condition permitting rather rapid evaporation and shrinkage of the cheeses. The prevention of one or both of these extremes is one of the common difficulties.

A factory manager of experience puts the proper time in the hâloir, or first room, at ten to thirteen days. In the further ripening several practices are found. The ideal French practice, according to

FIG. 3.—" Halloir " or first ripening room in American Camembert factory, showing arrangement of shelves and cheeses upon them.

the same manager, transfers the cheese from the first room to the "sechoir" (second or drying room) as soon as the moldy rind with traces of bacterial slime is properly established. In this room the ventilating windows are opened and the evaporation of the extra moisture is accomplished. The cheeses are shrunk from 1 to 3 ounces in weight and reduced in size until they exactly fill the boxes. They are then packed and crated for further ripening. To insure ideal conditions such cheeses should now go to a ripening cellar to be finished for market. When they come from the second room, softening should have just begun. In the ripening cellar evaporation should be but slight, and the further ripening should be carried as near completion as the market will permit before shipment.

In actual practice, however, makers both in America and in France have often used but one room, the so-called "halloir," in

FIG. 4.—"Sechoir," second, or drying room in American factory, arranged as in a French factory.

which atmospheric conditions have been kept sufficiently dry to bring the cheese to the desired size and appearance in about two weeks in warmer parts of the season. The cheeses are then boxed and crated for ripening or for market. The difficulty of obtaining the desired conditions in the two rooms has often led to this substitution of one for two rooms, with very commonly a resultant loss of character to the cheese. Either the room is too dry, which produces cheese lacking in moldy covering, shrinking and becoming hard too rapidly, or it is kept too wet, so that ripening develops very rapidly, and the cheeses must be sold partly ripe or lost. Either extreme changes the character of the ripening. In both cases the tendency has been to box and pack the cheeses while still containing too much water, which has led to unpleasant odors and unsatisfactory appearance in the ripened product. Since the market demand for cheeses fully ripe has more and more superseded the trade in half-ripe cheese in America, it has become increasingly difficult to run factories as at present arranged.

Fig. 5.—Another part of the French factory shown in fig. 2. Observe long windows in "sechoir" at right. (From Twenty-second Annual Report, Bureau of Animal Industry.)

EQUIPMENT OF RIPENING ROOMS.

For ripening Camembert cheeses a particular form of shelves has been developed. The permanent part of these consists of posts from floor to ceiling of 2 by 2 or 2 by 4 lumber, in sets of four, 5 to 6 feet apart. In each group the posts are connected in pairs by permanent crossbars of similar size about 1 foot apart, from floor to ceiling, nailed or bolted to the inside of the posts, as shown in figure 3. Frames of strong lumber are made to fit exactly between these uprights resting on the crossbars. These frames are composed of strong side and end pieces and lighter cross strips.

Each frame is covered by a piece of coarse matting ("clayons"). This consists of thin round strips of wood held 1 to $1\frac{1}{4}$ inches apart by wire strands. The cheeses lie directly upon this matting. A cheese will rest upon three or four strips so that the surface is almost entirely exposed to the air. Such frames carry about 90 cheeses each. Two frames exactly fill the area between four posts, so that all the cheeses are within reach from the sides.

Windows well screened should provide abundant light for working in these rooms. Artificial light (aside from electric) is undesirable because of vitiating the air. There is no advantage in dark rooms, because experiments indicate that the trouble from fly maggots is greater under dark conditions than in fairly well lighted rooms.

Ripening boards.—Smooth boards 8 to 9 inches wide and exactly long enough to rest upon the same supports are used to replace the

FIG. 6.—Another French factory, showing large windows, with blinds, in "sechoir" on second floor. (From Twenty-second Annual Report, Bureau of Animal Industry.)

frames and the coarse or grating-like matting during the later stages. These boards are wide enough to carry two rows of cheeses, and they are smooth to avoid the tendency of the cheese to stick to the wood. The cheeses should be removed to the boards before softening begins. If left upon the mats (clayons) the strips of wood begin to cut into the ripened cheese as soon as softening commences.

Before making any recommendations about factory construction we must first discuss the problems and conditions of ripening, so far as they have been worked out. Factory construction must supply these conditions as closely as possible.

THE NEWLY MADE CHEESE.

Let us first examine the newly made cheese. At twenty-four hours old such a cheese commonly contains from 60 to 70 per cent of water.

It should contain a little less than 60 per cent after salting is completed and the cheese is ready for the ripening process.

As indicated in the discussion of Table 1, a cheese ready for market contains about 50 per cent of water. During the ripening process, therefore, the cheese must lose about 10 per cent of its weight. In actual practice the composition of newly made cheeses will vary considerably from day to day under the most careful management. In most cases these variations are due almost entirely to the rate and amount of drainage. The weight of different cheeses and different brands of cheese in the market runs from 10 to 12 ounces. The amount of loss of weight during the entire ripening process varies, probably, from 8 to 12 per cent; that is, from 1 to 1½ or even 2 ounces for each cheese. Attempts to eliminate this water in the making process have not thus far in our work produced cheeses of the best texture and flavor. The presence of part, at least, of this extra water in the earlier stages of ripening appears to have some necessary relation to the proper development of the ripening agents and to their action.

A ripening process to be successful, therefore, must take into account the composition of the freshly made cheese, the changes of this composition sought in the fully ripe cheese, and the biological conditions under which those changes can be produced. During the ripening process, therefore, the factors to be watched become very largely biological. The details of handling must be based upon an appreciation of the proper appearance and feeling of the cheese at its various stages of ripening. A brief consideration of the agents of ripening and their several parts in the ripening process must be introduced here.

THE RIPENING AGENTS.

The organisms concerned in Camembert cheese ripening have been discussed in previous papers.[a] Within the cheese, under normal conditions, the lactic organisms are always the most numerous species present. Other species in smaller numbers are found in freshly made as well as in fully ripe cheeses. Mazé attributes to the lactic organisms not only the souring of the curd but part of the proteolytic action in cheese ripening. This latter effect is said to begin after other agents have reduced the acidity first produced. Of the other organisms present no species so far studied has shown by its numbers, by the uniformity of its presence, or by its effects when introduced into experimental cheeses that it bears any important relation to cheese ripening. The souring of the curd and the production of certain flavors by the continued action of particular races or varieties of lactic bacteria are the changes that have been surely attributed by our work to presence of the bacteria inside the cheese.

[a] Bulletins 82 and 109, Bureau of Animal Industry.

The processes which transform the curd in three or four weeks from the hard, sour, undigested condition into the soft, smooth, buttery consistency of ripe cheese appear, therefore, to be attributable to the organisms found in the rind; that is, in the surface one-eighth of an inch or less. The species present are the Camembert mold (*Penicillium camemberti*, or its white form, *P. camemberti* var. *rogeri* Thom), *Oïdium lactis*, and the species of bacteria which, with *Oïdium lactis*, make up the reddish slime so commonly found upon the surface in the later stages of ripening. Other studies (by Dox and Thom) have shown that the characteristic appearances of ripe Camembert are due to very complete chemical changes of the casein; the fat is little affected. The Camembert mold (*P. camemberti*) has been shown to produce enzymes capable of causing these textural changes in the required time, but not capable of producing the flavors found. Other researches by various authors show that *Oïdium lactis* acting alone is able to cause more or less similar chemical changes, but that the texture produced is different. The oïdium, however, is shown to produce a flavor which forms part, at least, of the characteristic flavor of Camembert cheese. This organism forms a considerable part of the rind in all cheeses studied. It penetrates rather more deeply than the regular Camembert mold. Its presence has been demonstrated in the thin white layer commonly seen just under the rind of old cheeses. Together with the several species of bacteria it is found also in the reddish slime, of which it is always a part.

The part played in cheese ripening by the several species of bacteria found in this slime has never been fully worked out. The presence of the reddish slime covering, or partly covering, the cheese in its later stages of ripening is generally found associated with the presence of excellent flavors and textures. So close is this correlation that the presence and proper development of the red color is a common basis for judging cheese in the factory and in the market. Excellent textures can be found, however, in cheeses entirely lacking the slimy covering, but such cheeses are either mild in flavor or at best lack uniformity. Without proving its exact function in the process, the presence of the slime is certainly associated with or is a result of the conditions under which the best cheeses ripen.

Mazé attributes to the organisms of the rind (molds and bacteria together) the neutralization or destruction of the acidity of the curd. He considers their proteolytic action, although admitted to be present, undesirable in character, and therefore to be kept as small as possible. This view of cheese ripening attributes the production of ammonia to the organisms of the rind, together with minute amounts of substances which give flavor to the curd. The ammonia is said, then, to neutralize acidity and assist in dissolving the casein, but the bacteria inside the cheese are regarded as the chief agents of the best ripening. Aside from this the organisms of the rind are said to form a necessary protective coating which prevents the access of air to the cheese and so prevents the odors and flavors of rancidity.

Several species are present in all cases, although the exact determination of the part each plays in the ripening of a cheese is not fully known. Cheeses can be ripened to approximately the same appearance while differing markedly in the balance maintained between the various species. It is most probable that the result is more or less composite in every case. Certain conditions are, however, very definitely referable to a predominance of particular species. A particular flavor and texture, such as has been obtained with considerable uniformity by the makers of certain brands, represents a fairly uniform balance of the activities of these organisms due to uniform handling by makers and dealers for long periods of time.

OÏDIUM RIPENING.

Upon Camembert curd *Oïdium lactis* will spread over the surface of a cheese within the first forty-eight hours in a warm room. If permitted uninterrupted growth this organism will, inside the first week, produce irregular ridges and wrinkles upon the surface of the mass with a layer of liquefied cheese below this. This liquid layer develops a high flavor. The same conditions which permit this rapid development of *Oïdium lactis* favor the development of innumerable yeasts and bacteria upon the rind of the cheese with the oïdium. These bacteria give a yellowish color to the surface and produce strong and often offensive odors.

Such a rind is thin, breaks easily, and peels off, hence must be handled carefully or the cheese is lost. Continued action of the oïdium without Camembert mold may increase the liquid layer, but fails to produce a smooth texture to the center of the cheese. The growth of an excess of oïdium indicates either cheese with too high a water content at the start, or too wet an atmosphere in the room—even a condition in which a change of air by ventilation causes the deposit of water rather than drying. Oïdium is so nearly always present in milk and milk products that special measures to obtain it do not seem to be necessary. It is associated with the ripening and peculiar flavor of Limburg and d'Isigny as well as Camembert cheese. Experiments and observations in cheese cellars indicate that oïdium will displace Camembert mold in very wet cheeses or in saturated atmosphere, but that proper drainage of the cheese followed by a very gradual evaporation restricts the growth of the oïdium and bacteria more than of the Camembert mold. It is thus possible by control of conditions to obtain any desired balance between the organisms. If this evaporation goes on too rapidly or the curd is too dry at the start, both of these organisms are so handicapped that the native molds present as spores in nearly all milk develop, to the injury of appearance and flavor.

OTHER ORGANISMS OCCURRING ON CAMEMBERT CHEESE.

In addition to the organisms necessary to ripening, a large number of species of molds, yeasts and bacteria are constantly found. The essential species are always found upon good cheese, but almost never without more or less admixture of species unnecessary or even very objectionable. Some of these change the appearance of the cheese; others produce odor or flavor. Some, for example the yeasts, may be present in immense numbers without appearing to exert any marked influence upon the ripening process. The presence of these various species and possible damage from them must be kept in mind in every discussion of the handling of milk and milk products.

Of the molds that may appear a few require special mention. Roquefort mold (*Penicillium roqueforti*) is often found on Camembert cheese. When present it gives a bitter flavor to the cheese, offensive to some tastes, appreciated by others. The true flavors of Roquefort cheese produced by this mold do not appear within the ripening time of Camembert. The most troublesome molds are those which give a strongly ammoniacal odor—*Penicillium brevicaule* and two related varieties. *P. brevicaule* is recognizable by the yellowish-brown patches formed upon the old cheeses. The varieties are both white or slightly creamy in color. Under wet conditions these form "cottony" patches almost mistakable for mucors. Under dry conditions the spores are produced as a white dust or powder on the surface of the rind. Once learned, the odor immediately betrays the presence of these forms. They are very generally present upon the cheeses imported from France.

No practice observed eliminates such molds entirely, though they are especially offensive upon cheeses when a heavy moldy rind has been developed. If conditions of ripening are properly maintained, the injuries from these other species are at the same time reduced to the minimum.

Green molds sometimes become very numerous in a factory, especially where several lines of work are going on in the same building. The mold spores are extremely light, float in the air, and lodge in inaccessible places. They may be reached and carried down by filling the air with steam. When the steam has condensed, the thorough spraying and washing down of the walls and floors will relieve the trouble. But the organisms regularly infecting the cheese are not reached by such means. These are avoided only by strict cleanliness of handling and the vigorous destruction of badly infected material.

CONDITIONS OF RIPENING.

The conditions of ripening must permit the proper development of the organisms sought, yet maintain such a balance between their activities that the cheese when ripe will satisfy the trade. Three factors affect the activity of the molds and bacteria during the ripening process: (1) The initial percentage of water present in the cheese, (2) the temperature of the room, and (3) the relative humidity of the atmosphere.

PERCENTAGE OF WATER.

As already noted, cheeses are usually drained to a little less than 60 per cent water during the making and salting process. No two lots drain to exactly the same percentage of water, but tests of cheeses which resembled as closely as possible those seen made in the factories show the cheeses to contain about 10 per cent more water at the beginning than at the end of the ripening. The cheese maker must be able to judge by the feeling of the cheeses how closely they approach such an average condition. When above or below the average in water content special care would be needed to obtain the best results. Comparison of various makes of cheeses indicates that particular factories or groups of factories maintain fairly close conformity to a certain ideal; other factories or groups set the ideal somewhat higher or lower. The resulting cheeses, therefore, as found in the market, show the differences of their handling by contrasting textures, appearances, and often more or less intense flavors.

TEMPERATURE.

Factory observation and experiments agree in fixing the best limits for work at 52 to 58° F. (12 to 15° C.). Although many factories in France make little provision for artificial heat, these limits would include the larger part of the practice where temperature is controlled. If the rooms are colder, development is delayed without advantage. If the rooms are much above 58° F., the growth of all the organisms present becomes disproportionately increased, the proper balance between their activities is lost, and rapid decay may be expected. The selection of temperature within these limits becomes a matter to be determined by local conditions and the judgment of the maker. The more rapid ripening occurs at the higher temperature. Considerable control of results is therefore possible from small changes in temperature.

RELATIVE HUMIDITY.

The humidity of the air in the ripening rooms is, if possible, even more important than the temperature and the initial water content of the cheeses. The percentage of relative humidity controls the rate of the evaporation of water from the cheese. As the humidity of the air in the room approaches saturation (100 per cent) the rate of evaporation from the cheeses diminishes until a point of equilibrium is reached above which no water is lost, or moisture is even condensed upon the surface. At that point the vapor tension of the cheese exactly equals that of the surrounding air. This point of equilibrium differs for cheeses of different water content. It is considerably higher for cheeses at 60 per cent water content than for cheeses at 50 per cent. In one experiment about 150 grams of cheese testing about 65 per cent water evaporated at the rate of 1 gram per day, whereas a similar amount of cheese testing about 10 per cent less lost weight at the rate of only 0.3 gram per day in the same room at a relative humidity approximating 88 per cent. Although the temperature was low, the sample high in water content showed marked signs of decay in ten days under these conditions. A relative humidity of 88 per cent was manifestly too high to handle cheese as wet as this. The other was found in excellent condition.

Cheeses enter the ripening period with about 8 to 10 per cent excess of water, which must be lost during the process. The humidity of the air surrounding the cheeses must therefore be so handled that this excess of water may be removed. Under factory conditions thousands of cheeses are placed in one room. Ventilation must therefore be provided sufficient to carry away large aggregate amounts of water, but must be controlled so that the rate of removal shall not cause shrinkage and hardening. The working temperature ought not to be affected seriously by this ventilation.

If the relative humidity becomes too high, water gathers in beads and drops upon the walls and ceiling and upon the cheeses and bacterial growth becomes much more rapid than mold growth. Mold may even be suppressed entirely. Under these conditions the cheese develops strong odors and tends to liquefaction and decay. Too wet conditions are usually most quickly detected by the presence of loose floccose colonies of white shimmering mold (*Mucor* species).

If evaporation is too rapid, the danger signal is quickly noted by passing the fingers over the edges of the cheeses. Hard knifelike edges indicate too rapid drying. The cheeses should feel moist (not wet) to the very edge. Under too dry conditions patches of green mold appear quickly. Various species of Penicillium will grow upon curd. When the conditions are right Camembert mold will overgrow most of the useless or noxious forms. When the air and the curd become drier this advantage is lost, so that the appearance of green patches becomes an evidence of such dryness.

Between the wet and dry limits described there is considerable latitude in which the results obtained differ greatly with the details of management. The general principles already discussed apply equally to all practices.

Within these limits of humidity two extremes of practice may be described. In one the humidity of the air is kept approximately uniform, so that the fresh cheeses properly drained evaporate somewhat rapidly, but the rate of evaporation gradually falls to a condition of equilibrium by the time the cheeses have reached the proper moisture content. This period should be two to three weeks, according to the temperature used. During the further ripening little, if any, loss of weight should occur. In such a scheme a single room is used—the halloir.

In the other the humidity is kept as high as the condition of the cheeses will permit, until the rind with its organisms becomes well established and reaches the desired balance between mold, oïdium, and reddish bacteria. This requires, according to its advocates, ten to twelve days if successful. Cheeses must be removed from this room as soon, however, as they have reached the proper appearance. They are then taken to the second room, or "sechoir" (drying room), where the remaining excess of water is dried out quickly, so that they reach nearly the same condition in about the same time as in the practice first described. The change in water content is accomplished differently, however. The latter practice on the whole probably produces stronger flavored cheeses than the former. Between these extremes many variations are practiced. The many differences in texture and flavor in the imported cheeses may be accounted for in such differences of handling.

OTHER CONDITIONS.

A detailed discussion of the observations and appearances during the various stages of normal and abnormal ripening will explain many points in the process.

Under normal conditions a cheese will begin to feel "greasy" in two or three days. Examination of its surface will show some growth of oïdium and often various species of yeast. The normal process of souring, if successful, reduces the growth of bacteria (other than lactic species) to a minimum until a later period. By the end of a week in the ripening room colonies of Camembert mold should be definitely visible; within ten days of ripening such colonies if undisturbed will assume the gray-green color indicative of ripe conidia. The best practice calls for a thin or somewhat incomplete covering of mold, well distributed, however, over the surface of the cheese. While upon the mats (clayons) in the first room (halloir) this moldy covering is commonly heaviest upon the underside of the cheese if it remains unturned for a considerable time. If allowed to stand on a board during this time the mold will grow so firmly to the wood that the cheese will be broken in removing it. Frequent turning therefore tends to insure well-distributed mold. If a side or any considerable area lacks mold entirely it becomes covered with bacteria and oïdium, which make a greasy, soft rind and lead rapidly to overripeness, bad flavors, and decomposition if water content is still high. On the other hand, if mold is permitted to develop in a dense mat over the whole cheese it produces a ripening of excellent texture, but as a rule one lacking in flavor. Such a cheese is creamy in texture and flavor, but is often found to have none of the characteristic flavor of Camembert. The appearance of the heavy, moldy rind is objected to by many. The flavors sought seem to be attributable to a combination of the effects of the two molds under conditions favoring the development also of slimy bacteria. Successful ripening must depend upon the balancing of the activities of these organisms. If handled perfectly there is very little if any growth of Camembert mold after the first two weeks. As Dox[a] has shown, after the mold has begun to produce spores there is a rapid escape of the ripening enzyme from the mold into the cheese. Just at this time—the tenth to fourteenth day, according to conditions—the softening of the curd under the moldy rind begins to be noticeable.

THE CLIMATIC FACTOR.

The preceding pages present the general results to be obtained and the approximate limits within which the work can be done. The working equipment for reaching these results remains to be discussed. Aside from the occasional farm, the factory is the unit of production. In building the ripening rooms, the conditions of cheese ripening must be furnished. Either upon the small or the larger scale, a great variety of equipment can be utilized. Where small numbers of cheeses were made in France the work was done in parts of dwelling houses or in outbuildings adapted for the purpose. Better equipment and more uniform results begin to be obtained when the output reaches 200 to 400 cheeses a day, which is perhaps the limit of production without the construction of expensive buildings.

The economies of equipment and administration begin to be possible when the number of cheeses reaches 1,000 to 2,000 a day. The factories built in America have reproduced types of construction common in France. Although large numbers of good cheeses have

[a] Bulletin 109, Bureau of Animal Industry, U. S. Department of Agriculture.

been made, the work has been attended with many losses which were found difficult to explain. The discussion of ripening conditions already given, however, points to the probable cause of many of these troubles. The biological factors in cheese ripening demand that temperature be kept within quite narrow limits and that the relative humidity be kept quite high, perhaps 85 per cent. Without disturbing temperature or relative humidity, provision must be made to evaporate about 10 per cent of water from every cheese. The aggregate is large if we figure that the factory must accommodate at least twenty days' make (10,000 cheeses for a small factory) and evaporate at least 1 ounce from each. Air already at 80 to 85 saturation takes up little water, hence the rate of change of air must be rapid. The climatic factor in ripening is thus introduced. In general this may be stated as follows: If the atmospheric temperature be higher than the working temperature, the air for ventilation must be cooled. Cooling raises the relative humidity toward the dew-point (saturation). If, on the contrary, the weather be cold, the air must be warmed; but, in heating, air increases its capacity to absorb water. Since the water is not present in such air when it is introduced into a ripening room, water is rapidly absorbed from the cheeses.

To furnish working conditions, both temperature and relative humidity must average closely enough to the limits of cheese ripening to permit of successful adaptation to the demands of the process.

COMPARISON OF AMERICAN AND FRENCH CLIMATIC CONDITIONS.

In seeking a basis for comparing American with French conditions a table has been made from published weather reports of both countries. In the published reports, mean temperature and mean percentages of relative humidity are given for each month of the year. The French figures have been selected from various published tables to show the mean temperature and mean relative humidity of the whole region as completely as possible without complicating the table. Extremes of temperature are given in some cases to indicate the most rigorous conditions to be expected, in order to compare with the American figures which follow. The latter are taken directly from Stockman's paper,[a] except that the "mean" column was averaged from the monthly mean maximum and minimum temperatures. When possible the number of years recorded in compiling the figures is indicated in the table.

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[a] Stockman, W. B. Temperature and Relative Humidity Data. United States Department of Agriculture, Weather Bureau, Bulletin O (W. B. No. 334). 1905.

TABLE 3.—*Mean temperature and relative humidity of points in France and in the United States.*

	Caen, altitude 69 feet.		Paris,[a] altitude 256 feet.		Ecorchebœuf,[b] near sea.		Le Havre.	Rouen, altitude 39 feet.
Years observed	15	7	15	7	....	....	7	15
Month.	Mean temperature.[c]	Mean relative humidity.[d]	Mean temperature.	Mean relative humidity.	Mean temperature.	Mean relative humidity.	Mean relative humidity.[d]	Mean temperature.[c]
	°*F.*	*Per cent.*	°*F.*	*Per cent.*	°*F.*	*Per cent.*	*Per cent.*	°*F.*
January	39.9	85.0	37.2	87.4	37	88	86.0	39.9
February	43.7	81.7	40.2	86.2	40	87	84.0	41.9
March	46.2	81.5	44.6	77.0	43	80	80.7	45.1
April	51.1	80.0	50.3	71.3	47	78	77.5	50.7
May	55.4	81.0	55.4	71.7	51	77	77.3	55.6
June	60.8	80.0	61.8	74.9	57	80	77.5	61.5
July	63.9	80.7	66.0	75.9	61	80	78.0	65.7
August	63.3	82.4	65.0	76.1	61	82	79.0	65.1
September	59.0	83.0	59.0	83.5	57	85	81.4	60.1
October	51.3	86.0	50.4	87.1	50	84	83.0	50.8
November	45.7	86.0	43.2	87.2	43	85	85.0	44.2
December	40.3	86.0	37.0	91.1	38	89	87.0	39.5
Mean	51.7	82.9	50.8	80.6	....	....	....	51.6
Highest temperature	....	....	....	....	79–92	....	....	....
Lowest temperature	....	....	....	....	12–3	....	....	....

	Alençon, altitude 450 feet.	Albany, N. Y., altitude 97 feet.				Binghamton, N. Y., altitude 875 feet.			
Years observed	15	26				8			1
Month.	Mean temperature.[c]	Temperature.			Mean relative humidity.	Temperature.			Mean relative humidity.
		Mean.	Mean maximum.	Mean minimum.		Mean.	Mean maximum.	Mean minimum.	
	°*F.*	°*F.*	°*F.*	°*F.*	*Per ct.*	°*F.*	°*F.*	°*F.*	*Per cent.*
January	37.9	23.0	31	15	80.4	25.0	33	17	81
February	40.3	21.0	32	16	78.9	23.0	30	16	80
March	41.4	32.0	40	24	76.9	33.0	41	25	81
April	49.5	47.0	56	38	69.3	45.5	55	36	76
May	54.5	59.5	69	50	71.4	57.0	67	47	78
June	61.5	68.5	78	59	71.9	66.0	77	55	77
July	65.7	73.0	82	64	71.9	72.0	83	61	74
August	64.8	71.0	80	62	75.7	69.5	80	59	83
September	60.3	63.5	72	55	77.3	62.5	73	51	89
October	50.5	51.5	60	43	79.3	52.5	63	42	92
November	43.7	39.0	46	32	80.7	38.0	45	31	91
December	38.1	29.0	36	22	81.3	28.5	35	22	76
Mean	50.9	48.5	57	40	76.2	45.5	57	38	
Highest temperature		100° July.				96° July, Aug.			..
Lowest temperature		-24° Jan.				−26° Jan.			..

[a] Relative humidity data for Paris are very completely discussed in Annales du Bureau Central Météorologique de France, 1880, B. 106.
[b] Ecorchebœuf is 9 miles from the sea, between Rouen and Dieppe. Full data for this station are given by Moureaux in Annales du Bureau Central Météorologique de France, 1890, vol 1.
[c] Report of Voyage of H. M. S. *Challenger*, 1873–1876, Physics and Chemistry, vol. II, pp. 202-204.
[d] From Annales du Bureau Central Météorologique de France, 1899-1905.

TABLE 3.—*Mean temperature and relative humidity of points in France and in the United States*—Continued.

	Milwaukee, Wis., altitude 671 feet.				San Francisco, Cal., altitude 153 feet.			
Years observed	14				14			
Month.	Temperature.			Mean relative humidity.	Temperature.			Mean relative humidity.
	Mean.	Mean maximum.	Mean minimum.		Mean.	Mean maximum.	Mean minimum.	
	°*F.*	°*F.*	°*F.*	*Per cent.*	°*F.*	°*F.*	°*F.*	*Per cent.*
January	20.0	27	13	78.4	50.0	55	45	79.7
February	22.5	30	15	77.6	52.5	58	47	77.9
March	30.5	37	24	77.6	54.0	60	48	77.5
April	44.0	51	37	73.1	55.0	61	49	77.9
May	53.5	62	45	71.2	57.0	63	51	79.0
June	63.5	72	55	73.4	59.0	66	52	80.1
July	70.0	78	62	70.6	59.0	65	53	84.4
August	63.5	76	51	72.6	59.0	65	53	85.8
September	62.0	70	54	74.4	61.0	68	54	81.1
October	50.5	58	43	75.6	59.5	66	53	78.6
November	36.0	43	29	76.9	56.5	62	51	77.3
December	26.5	33	20	77.4	51.5	56	47	79.7
Mean	45.0	53	38	74.9	56.0	62	50	79.9
Highest temperature	100° July.			....	100° June.			....
Lowest temperature	−8 to −25° Nov., Mar.			....	29° Feb.			....

A study of this table is instructive. Caen is near the western edge of the section where the largest amount of Camembert is produced, but probably represents a fair average of the working conditions. It will be noted that in no month does the mean temperature fall below 39° F. The lowest average of minima for any month was about 33° F. The mean relative humidity does not fall below 80 per cent, while in the eight busy months—August to April—it is still higher. Ventilation is practically possible by letting outside air enter at open windows at almost any time in the year without introducing freezing temperature or excessively dry air. A small amount of artificial heat will produce the needed temperature at any time. There are but two months of the year when the temperature is too warm for work within the desirable limits already given.

Compare with these the figures for the American cities listed, excepting San Francisco. The averages for September, October, and November are close enough in some cases to those given for Caen to suggest success. In December, January, February, and March our relative humidity, at best, falls several per cent below that of Caen, while the mean air temperature is 10 to 20° F. lower. Examination of the full reports of variations in temperature, of daily maxima and minima, discloses more striking contrasts than the monthly means. Nature has furnished the French factory a set of working conditions which requires only the opening and closing of the windows with at times a moderate amount of artificial heat. San

Francisco alone of the American cities given is found to have climatic conditions even approximating those of Normandy. In the regions represented by the other American cities the mean temperatures from May to September are mostly prohibitive of work because too warm; from September to December they suggest possible success; from December to March mean temperature and often relative humidity are both low. Not only are the means low, but the variations are greater. Cold northwest storms bring conditions much lower and last often a week or more at a time. Factory managers report that such storms mean the drying out and often the ruin of a large part of the cheeses in stock. Such a storm is said to cause the cheeses to shrivel up as if in a warm, dry room. To obtain working conditions the outside air must be warmed at least 10 and often 20 to 30° F. In this process its percentage of relative humidity falls still lower.

A problem may be given to illustrate conditions in a ripening room at Albany under average conditions for January: Mean temperature, 23° F.; mean relative humidity, 80.4 per cent; 1 cubic foot of air saturated (100 per cent) relative humidity at 23° F. contains 1.488 grains of water; at 80.4 per cent, 1.196 grains of water. The same cubic foot of air heated to 50° F. would hold at saturation (100 per cent) 4.076 grains of water. But as introduced it does contain 1.196 grains. Its percentage of relative humidity is therefore $1.196 \div 4.076 = 29.3$. If the working temperature were lowered to 40° F. the corresponding figure would be about 40 per cent relative humidity. Such air introduced into the ripening room absorbs water rapidly until a point of equilibrium is reached. This water comes from the cheeses. It is thus impossible to introduce outside air into these rooms without rapid drying from the lowered relative humidity of the atmosphere. Both the temperature and the relative humidity of the air introduced must be raised within working limits before the rooms can be ventilated without injury to the cheeses.

Instead of free ventilation, as in Normandy, this air under the present practice must be introduced through the making room, where it absorbs moisture, or ventilation must be reduced until the change of air is nicely balanced by the amount of evaporation desired. No instruments have been found which give a practical and immediate check upon the humidity relations in such rooms. Unless the cheesemaker is extremely careful, unfavorable conditions are detected only after their bad effects have been wrought upon the cheeses.

Binghamton is in the same district as the factories which have made Camembert in New York State. One factory reports success during parts of October and November and at no other season. The report given for Binghamton covers a single year, 1898. A glance at these figures shows that only during October and November do mean temperature and relative humidity both approach the average for Normandy. At any other season the climatic conditions make success only attainable by artificially producing the proper temperature or humidity, or both. Factories built for French conditions have actually produced fine results a few weeks of each year, and caused numerous difficulties and losses at other seasons.

The table brings out, therefore, the contrast between the climatic conditions of dairy sections of the United States and those of Normandy. The question remains, Can Camembert cheese manufacture be made successful in spite of these conditions? The factory manager already quoted has said: "The Camembert season in America is just about six weeks—October 15 to December 1." This assumes a factory built and run as it would be in northern France, but it also results from seven years' experience with that factory. In that time several hundred thousands of Camembert cheeses were made and sold. Large losses year after year led finally to the closing of this factory, which was built and operated originally by a French family, who continued to operate a factory in France during the same time and who have done so since this was closed.

Several other companies have had more or less similar experience and abandoned the effort or curtailed the product on account of similar troubles. The partial successes obtained in these factories have been best secured in the two or three autumn months which are indicated by the table as reproducing French climate most closely. Similarly, in experimental work at Storrs, Conn., excellent results have been obtained in the same months. Aside from this short period, it has been necessary to determine the conditions needed and to produce them or fail to get good cheeses. When the conditions have been right, good cheeses have been readily obtained. At all other times experimental cheeses were lost.

Both factory operations and experimental work thus show that unfavorable climatic conditions in the United States must be overcome during a considerable part of the year before continued success can be hoped for. To overcome these difficulties, either the location of the factory must be determined by the presence of the climatic conditions desired or the construction of the factory itself must make possible the production of those conditions when necessary. The former would permit Camembert cheese making in very few, if any, places in the Eastern States; there is, however, some reason to hope that this would be successful on the Pacific coast. It is already introduced in the neighborhood of San Francisco. If success is to be attained in the Eastern States the factory must be so built as to enable the cheese maker to furnish the conditions required, irrespective of outside temperature or humidity.

CONSTRUCTION OF ROOMS FOR CHEESE RIPENING.

Since French factory construction has failed in America in the hands of experienced Camembert makers from France, some changes are necessary. Such changes must enable the cheesemaker to minimize the effects of sudden and violent changes of temperature during the winter months, and little or no Camembert can be made under prevailing conditions from May to August. To produce this effect two possibilities are open: (1) Buildings upon the present plans but thoroughly protected from cold winds, insulated against heat and cold, and furnished with efficient systems of controlling ventilation; (2) factories with their ripening rooms partly or entirely below the surface of the ground and furnished with equally good apparatus for ventilation.

Both systems offer advantages. The factories at present built are successful part of the time. If better protected against changes of weather and supplied with efficient means of insuring proper moisture conditions, the same buildings may perhaps be used successfully. Without such alterations they appear to have failed as investments. If correction of their failures is possible their use would involve the least change of methods on the part of the workmen. If the whole ripening process be carried on in rooms partly or entirely below ground, the exposure to storm would be reduced, the production of uniform temperatures would be much easier, and the moisture of the soil would aid in maintaining the desired humidity, but means of producing and controlling ventilation would be equally difficult to manage during a large part of the year. Such rooms, if planned, should, if possible, run into the hillside and have opportunity for ample window space for lighting purposes.

In any plan of construction the apparatus (shelving, frames, mats, etc.) used in the French factories has proved its economy and efficiency.

With either choice of general plan, the space for ripening ought to be divided and arranged to enable the production of a series of conditions within the working limits of cheese ripening already discussed. The proposal of simply a "halloir" and a "sechoir" may be doubled to advantage. Instead of one very moist room and another quite dry, the same space may very desirably be divided into three or four rooms offering a series of conditions. One of these rooms, if the series be in a hillside, ought to be moist enough almost but not completely to stop evaporation. From this condition the other rooms may reduce relative humidity somewhat, and the series should have one room approximating the French "sechoir." The driest room or "sechoir," however, must still have the humidity of French atmosphere, which averages 83 to 85 per cent during the working season. This is a very different figure from our 70 to 80 per cent humidity, which drops much lower yet when we compensate for the necessary heating of this air before it can be introduced. Such a series should probably range in humidity from 90 to 92 per cent in the wettest to 80 to 83 per cent in the driest room.

If we study the conditions in a room full of cheeses we should find the air within that room to have higher relative humidity than the air outside. If we take an average mean humidity of 83 to 85 per cent as the condition in the Camembert region of France, the average "halloir" would probably test between 87 and 90 per cent when filled with cheeses, and at times higher. In order to transplant cheese ripening to America, therefore, we must get relative humidities approximating such figures.

STAGES OF RIPENING.

First two weeks.—Cheeses enter the first room (halloir) on the third day after making. They usually become sticky, with evidence of *Oïdium lactis* and often with the smell of yeast, within three or four days. In five to six days the white threads of Camembert mold begin to be seen. In nine to twelve days the colonies of Camembert mold show traces of colored spores. The colonies of Camembert mold appear as patches on the sides and edges or as a light covering well distributed, but they should not form a heavy felt all over. Areas uncovered or only partly covered with mold should show a marked slimy reddish covering. If the mold forms a heavy felt with the dark color of abundant spores it is called "black" and rejected as not first grade. If the room is too wet, oïdium, yeast, bacteria, and even white piles of mucor tend to displace Camembert mold entirely. As the humidity is lowered the activity of the Camembert mold increases proportionately to that of the slime organisms until a condition is reached in which every trace of slime is covered over by felt-like mycelium. Between the very wet condition and the optimum for mold growth we find the best condition for cheese ripening. A heavy covering of mold extracts water from the surface of the cheese and makes the rind too dry to permit the growth of the slime organisms. At its optimum Camembert mold will overgrow any other species which may happen to be present and at the same time dry the rind so that the bacteria and oïdium are much restrained, at least. If the moisture conditions are reduced from this optimum, the growth of Camembert mold will be reduced gradually until a percentage is reached at which other molds grow equally well. The appearance of colonies of common green molds indicates, therefore, that the air of the room or the cheeses, or both, are dry enough for the shrinkage of the cheese to become noticeable also. At the end of two weeks' ripening the rind of the cheese should be well established and the first traces of softening usually appear. If the rooms are kept cold, every stage of ripening may require double the amount of time needed at the limits suggested (52 to 56 or 58° F.). Cheeses low in water content require more time than those containing higher percentages of water.

A series of rooms rather than a single "halloir" offers several advantages. The cheeses made from day to day differ somewhat in condition as they are removed from the making room. If all go to one room kept at a theoretical average humidity, some become too wet and others too dry even when the condition of the cheeses which happen to approximate the average moisture content is satisfactory. With a choice of rooms, cheeses firm and possibly overhard may be kept under more moist conditions. The wet cheeses may be in a room with less humidity. Again, different markets call for varying ideals of ripening. Mild flavors and fairly firm textures can be obtained by ripening where a gradual but continuous evaporation is maintained. Moister conditions, with the consequent development of bacteria and oïdium, are associated with stronger cheese. Such cheeses may be ripened very soft or, after ripening is started, spend a few days in a "sechoir," or drying room, and come out with firmer texture. The treatment of the cheese should depend not only upon its texture and appearance, but also upon the ideals sought. With a series of rooms presenting different but known and controlled conditions one lot of cheeses does not need to be ruined to save others. By moving cheeses from room to room a much larger percentage of good results is obtainable than with less provision for control.

Third week.—During the first two weeks little or no changes in the sour curd are noticeable. A piece of litmus paper pressed against a cut cheese will show an acid condition, although at the end of this time the surface layers for perhaps one-eighth of an inch may test alkaline (blue). During the third week the ripening changes usually progress more rapidly, which will be indicated by a softening of the curd just under the rind. The line between sour curd and ripened cheese is a fairly sharp one, as shown by the softening of the texture. The change from an acid to an alkaline reaction can often be shown by pressing litmus paper against the cut edge of a cheese. The soft, well-ripened part in such cheeses reacts alkaline (blue). Ripe cheese is occasionally acid in reaction to litmus. It is usually, however, neutral or alkaline.

When this softening becomes noticeable at the edges of the cheeses they must be removed from the matting. The mold of the rind tends to grow fast to the wood strips, which cut into the cheese as softening begins. If they are not promptly removed areas of rind will peel off and adhere to the matting when the cheeses are removed.

Ripening on boards.—At this time, if further ripening in the same room is desired, the cheeses are placed upon the smooth boards with which the frames and matting are replaced. Where a second room or "sechoir" is used the cheeses now go into this room. They are turned on the boards, usually every day, to secure uniformity of ripening and to avoid losses from adhering to the wood and breaking. At this time the tendency to evaporation and shrinkage in size is very noticeable; hence the second room must be watched closely.

Red areas.—With the softening period and the constant turning of the cheeses on smooth boards the reddish or yellowish slimy areas increase in size until they often more or less completely cover up the moldy part of the rind. This increase calls for more moist conditions for its full development.

The rate of ripening is closely dependent upon temperature. At the low temperatures—50 to 54° F.—mold growth is still fairly rapid, but the rate of ripening is reduced. It is possible at about 60 degrees to produce cheeses almost completely softened at twenty-one to twenty-four days, when at 50 to 54 degrees a cheese may be less than one-half ripe in the same time. Cheeses high in water content ripen most rapidly; when containing less water the cheeses can be held at higher temperatures with less rapid softening.

Three to four weeks.—Cheeses ripened rapidly decay also more rapidly. It is difficult to hold a cheese ripened in twenty-one to twenty-five days for any length of time. In our experiments rapid ripening has been associated with such rapid decay that a ripening under four weeks has seemed to render cheeses too perishable for successful market handling. Many of our cheeses which became entirely soft in twenty-three to twenty-five days developed within two or three days after becoming fully soft ammoniacal odors and the peculiar flavor which one quickly learns to associate with overripeness. On the other hand, where the process has been prolonged to thirty days or more before complete ripeness the cheese retained acceptable flavor and texture for several days longer.

It is thus possible to reach much the same results in several ways. By making the drier cheeses and ripening at slightly higher temperatures we are able to reach good flavors and textures in the proper time without quick decay. Making a slightly wetter cheese and ripening at the lower temperature accomplishes the same result in the season of year when such cheeses can be handled. If the fully ripe cheese contains more than 51 or 52 per cent of water decay is quick and complete as a rule. When the water content is between 47 and 51 per cent, the fully ripe cheese is firmer and resists decay much longer.

Ripening in boxes.—In factory practice the ripening is rarely carried beyond the third week upon boards. Very often the boards are not used at all. In such cases the cheeses from the boards, or after they are removed from the matting, are wrapped in parchment paper (sometimes also in tin foil) and put in boxes and the boxes crated. Very few cheeses are as much as half ripened throughout when they are wrapped and boxed.

The stage of ripening at which this is done influences the final product considerably, as a rule. In experimental work it has been found that cheeses wrapped and boxed when two-thirds covered with mold (with the mold still white or faintly tinged with green) usually develop the stronger flavors. If the mold is allowed to go further and to cover the cheese completely and become colored before wrapping, the milder flavors are more common. Sometimes tin foil is used in wrapping cheese. This minimizes evaporation, making practically a sealed package, in which little or no mold growth occurs and even inhibits some forms of bacteria. Hard cheeses low in water content may in this way be made to soften completely. In general, tin foil wrapping prevents evaporation, hastens ripening, produces a more nearly liquid cheese, and leads to strong, almost biting, flavors. Some consumers prefer such cheeses, hence there are brands which regularly supply this demand, but the larger part of the trade does not use cheeses wrapped in tin foil.

Cheeses can be ripened fully, with excellent texture and flavor, upon smooth boards without wrapping at all. But as they soften they tend to break open and lose shape, which makes such ripening impracticable for the factory.

After boxing, the further ripening may be completed at the factory in a special room, as described above, or the cheeses are sent at once to market. In France, where the latter practice was observed, the purchasers who wished to supply fully ripe cheese in exactly the right condition unwrapped them and finished the ripening upon smooth boards in a cellar with air nearly saturated and temperature, as already described, perhaps 56 to 58° F.[a]

Fully ripe cheese.—The proper texture of a fully ripe cheese is a matter of preference. Good flavored cheeses, cheeses even of the same flavor, can be obtained soft enough to "run" when cut, or they may be of the consistency of moderately soft butter.

WHEN TO MARKET THE CHEESE.

The time of packing and shipping cheeses should depend upon the closeness of connection between factory and consumer. In sending cheeses to the general market in France and also in this country, the practice has been to keep the cheese in the factory until the mold has developed and the cheese has begun to show slime, that is, until

[a] Soft Cheese Studies in Europe. Twenty-second Annual Report, Bureau of Animal Industry, United States Department of Agriculture, p. 90.

the softening has begun slightly—perhaps one-fourth of an inch under the rind. The cheeses are then packed and sent to market. In particular cases (for special patrons or special markets) they have been allowed to ripen further. But in general the maker has endeavored to get the preliminary stages of ripening properly started, and then the cheeses are sent to the distributing center. Once on the market such cheeses either go to special cellars for finishing, which may be in the hands of the commission man or the actual user, as in cases of hotels, cafés, etc., or they may go direct to the retailer and be sold for consumption.

Much observation of the cheeses offered for sale at retail shows that in France very many such cheeses reach the private consumer less than one-third ripe.

THE AMERICAN MARKET.

In America most users of Camembert demand fully ripe cheese. Some prefer it just before complete ripeness, when there is a slight layer of sour curd in the center, while a very few ask for cheese with little or no softening. This complicates the problem of handling Camembert. The average consumer or even the dealer has not understood how to handle it at the various stages of ripeness.

The necessity remains, therefore, for the maker who sends cheese to the general market to send it so long before complete ripeness as to minimize losses from overripeness. At the same time, to sell fully ripe cheese to the consumer, the maker must ripen as far as he dares before selling. Careful study of the condition of the market emphasizes the desirability of the closest possible connection between factory and consumer.

SHALL THE FACTORY MAKE CAMEMBERT ONLY?

In establishing cheese factories it is generally good policy to combine the manufacture of several kinds of dairy products. The standard of milk for Camembert needs to be somewhat higher than is absolutely necessary for some other work. The ability to utilize all milk in reasonably good condition would save loss caused by refusing a patron's milk which might occasionally be unsuitable for Camembert, but could be used for butter or for other cheeses. Further, the factory should be able to take the milk throughout the year, while Camembert has not been handled to advantage in the United States during our hot months of summer. Some combination with other uses of milk should make work practicable throughout the year.

THE COOKING OF CAMEMBERT CHEESE.

That Camembert is a very perishable product has been repeatedly emphasized in these discussions. When fully ripe the marketable period is very short—a few days or a week at best—and even that time requires low temperature and care. It thus happens that losses in the American market have been large. Many of these losses have fallen directly upon the consumer who has bought the cheese at his own risk in the market and found it too ripe for his taste or having some of the flavors of overripeness or too rapid ripening, which are objected to by many persons. Experiments show that any cheese which is in condition to be selected by one even casually acquainted with Camembert can be used acceptably in cooking. The cheese need not, therefore, be entirely lost, even though higher in price than the kinds of cheese usually used in cooking.

Several brands of canned or tinned Camembert are obtainable. All are cooked forms of this cheese and suggest the possibilities of preventing loss of stock in this way. In America all soft-cheese trade has hitherto been irregular and uncertain. Dealers and makers have suffered from irregularity, especially in the demand for Camembert. Cheeses not sold are lost, as a rule. Cooking or canning under proper conditions offers a method of minimizing such losses.

MAKING CAMEMBERT CHEESE ON THE FARM.

As a general market proposition it is not advisable to undertake the making of Camembert cheese on the farm. In special cases, such cheesemaking may undoubtedly be developed to considerable advantage, but as yet these possibilities have not been really touched in this country. The making and ripening of the cheese in a certain household known to the writer has, however, been successfully carried on during the past year, although the cheeses produced have varied considerably in texture and flavor, and all have differed from the imported cheese in appearance. It may be doubted whether the uniformity demanded by the trade at present could be readily obtained when work is done with such small numbers of cheeses. The equipment used costs but a few cents in addition to the utensils already in the home. For ripening, a small zinc-lined refrigerator has proved capable of adaptation to produce approximately the conditions of ripening. With this or similar equipment it has been demonstrated that a busy housekeeper in the intervals of her work can make and ripen Camembert cheese enough to supply her own family and some of her friends.

In this instance the complex problems of producing Camembert cheese were fairly well mastered in a single season. At the same time no losses were necessary in the process, because every cheese was eaten in some stage or condition of ripeness, while repeated trials showed that Camembert cheeses, either lacking in flavor or too strong, could still be utilized in cooking. Thus the value of the materials used was recovered as acceptable food in the family in every case, since deficiencies in flavor did not prevent the use of the cheese as food. Although this work in its beginnings has cost a disproportionate amount of time for the food actually produced, the housekeeper who has already done this expects to continue to develop this work and to sell the product to advantage in a special market.

Camembert cheesemaking has been discussed in this paper mainly as a factory proposition. The production of this cheese for the general market will probably remain so in this country, just as it has become so in France. It is entirely possible, however, to produce cheeses of this type for home use wherever some member of the family will take the trouble to learn the work properly. The skill and expense entailed are no greater than the demands of many other lines of work already regularly carried on in the household for no larger return. In many special cases production can go further and very profitably supply the special personal market in the same way as many families now regularly supply butter or other products directly to customers.

The cheese made under these conditions would probably be refused if offered in the general market. The general market requires uniformity among large numbers of cheeses. This would not be reached by putting together the cheeses from a large number of farms so well as if all came from one factory. Where a small number of cheeses is made, control of conditions is more difficult. Cheeses will vary more from day to day, and they would require more care in selling than the dealer can afford to give. Products of this kind must be made for and delivered directly to a special market to obtain satisfaction for either party.

In the making of Camembert cheese on a small scale the problems to be met will seem new and strange at first. It will take some time to acquire the skill and judgment to work successfully, and especially to develop a considerable number of workers with such skill. But this is in no way impossible, and there are many situations in which those engaged in dairy work might regularly produce this kind of cheese from surplus milk and add materially to their profits without appreciably increasing their expenses. Like any other line of work worth doing, it must be learned well or it will lose for the investor both the time and money put in. Some markets will take hard cheese either good or bad and pay something for it, but soft cheeses, especially Camembert, are either good or good for nothing in the ordinary market. A family would be able to consume its experimentally made cheese, but not the output upon a larger scale. The conditions of each case should be well considered before Camembert cheesemaking is undertaken upon the farm. Under proper conditions it may be a source of both pleasure and profit.

In the vast majority of cases better results will be reached for the farm by perfecting the control of the production of milk than by attempting to market the milk produced as Camembert cheese. Comparatively few farms can combine these lines of work to advantage.

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PUBLICATIONS RELATING TO CAMEMBERT CHEESE.

The following publications have been issued by the United States Department of Agriculture or by Storrs Agricultural Experiment Station, Storrs, Conn. Those for which a price is shown may be secured only on application and remittance to the Superintendent of Documents, Government Printing Office, Washington, D. C. Others may be had by application to the United States Department of Agriculture, Washington, D. C., or to the Storrs Agricultural Experiment Station, Storrs, Conn., as the case may be.

CONN, HERBERT W.; THOM, CHARLES; BOSWORTH, A. W.; STOCKING, W. A., Jr.; and ISSAJEFF, T. W.

The Camembert type of soft cheese in the United States. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 71. Washington, 1905. Price, 5 cents. Also published as Bulletin 35 of Storrs Agricultural Experiment Station. Storrs, 1905.

DOANE, C. F., and LAWSON, H. W.

Varieties of cheese: Descriptions and analyses. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 105. Washington, 1908. Price, 10 cents.

DOX, ARTHUR W.

Proteolytic changes in the ripening of Camembert cheese. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 109. Washington, 1908. Price, 5 cents.

ISSAJEFF, THEODORE W.

Investigations in the manufacture and curing of cheese. Directions for making the Camembert type of cheese. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 98. Washington, 1907. Price, 5 cents. Also published as Bulletin 46 of Storrs Agricultural Experiment Station. Storrs, 1907.

THOM, CHARLES.

Fungi in cheese ripening: Camembert and Roquefort. U. S. Department of Agriculture, Bureau of Animal Industry, Bulletin 82. Washington, 1906. Price, 5 cents. Also published in Seventeenth Annual Report of Storrs Agricultural Experiment Station for the year ending June 30, 1905, pp. 73–115. Middletown, 1906.

Soft-cheese studies in Europe. U. S. Department of Agriculture, Bureau of Animal Industry, Twenty-second Annual Report, 1905, pp. 79–109. Washington, 1907.

The care and testing of Camembert cheese. U. S. Department of Agriculture, Bureau of Animal Industry, Twenty-fourth Annual Report, 1907, pp. 339–343. Washington, 1909. Price, 85 cents. Issued separately as Circular 145 of the Bureau of Animal Industry. Also published in New York Produce Review and American Creamery, vol. 25, No. 24, pp. 970–971. New York, April 8, 1908.

Popular descriptions and brief discussions of Camembert cheese are numerous in dairy text-books and journals. Only a few of the more important or more recent references consulted in preparing this paper are listed here. The chemical literature is reviewed and listed by Arthur W. Dox in Bulletin 109, Bureau of Animal Industry, cited above.

BOSWORTH, ALFRED W.

Chemical studies of Camembert cheese. New York Agricultural Experiment Station, Technical Bulletin 5. Geneva, 1907.

BUTTENBERG, P., and GUTH, W.

Über Camembert-käse. Zeitschrift für untersuchung der nahrungs-und genussmittel, band 14, heft 11, pp. 677–682. Berlin, Dec. 1, 1907.

This article gives comparative analyses of Camembert of many brands as found in the German market.

LEZÉ, R.

Preparation et maturation des caillés de fromagerie. Paris, 1905.

MAZÉ, P.

Les microbes dans l'industrie fromagère. Annales de l'Institut Pasteur, tome 19, No. 6, pp. 378–403, June 25; No. 8, pp. 481–493, Aug. 25; Paris, 1905.

MARGARET (pseudonym).

The practice of cheese making at home and abroad. The Creamery Journal, vol. 1, No. 11, pp. 313–315. London, July 20, 1905.

POURIAU, A. F.

La laiterie. Fromage de Camembert. Pp. 350–434. Sixième édition par Marcel Monteran. Paris, 1908.

ROGER, GEORGES.

La matière grasse dans les fromages à pâte molle. Communication faite au II^e^ Congrès National de Laiterie. Bruxelles, 1902.

La matière grasse dans les fromages à pâte molle. Communication faite au II^e^ Congrès International de Laiterie. Paris, 1905.

VAN SLYKE, LUCIUS L., and PUBLOW, CHARLES A.

The science and practice of cheese making. New York, 1909.

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