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Contents

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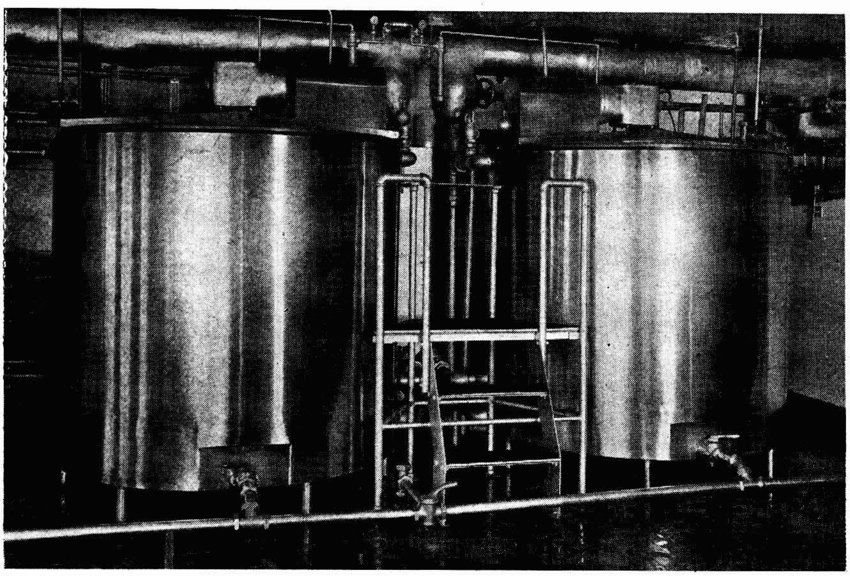

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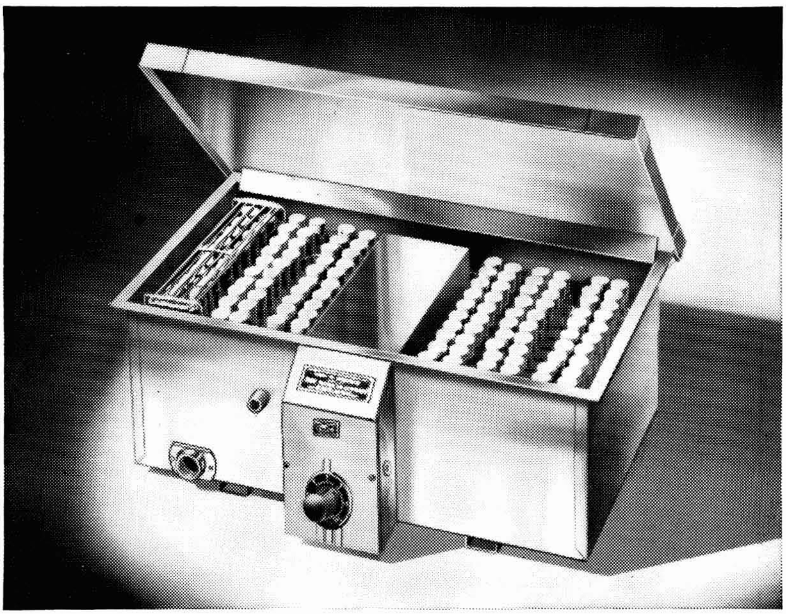

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RED MOLD ON BLUE CHEESE[1]

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During recent years there has been a great increase in the blue cheese production of the United States, particularly in the Middle West. As new plants have come into production and the older plants have increased their output, various problems have become important. One of these is the appearance of red areas of mold growth on the surfaces of cheese in certain curing rooms.

Commonly the red mold is first evident on the cheese as small, bright-red colonies which may be few or very numerous. The colonies usually are noted in 10 days to several weeks and increase in size, often rather rapidly, until they are 1 inch or more in diameter. If the colonies are rather numerous they grow together and form large red areas which make up a considerable portion of the cheese surface. Both the colonies and areas of mold growth have more or less irregular edges. In some instances blue or green mold growth is evident in the red growth, especially when the latter has been present for some time, but ordinarily the red growth continues to be dominant in the areas in which it has developed. The red colonies and areas are very conspicuous on cheese because of their bright-red color which contrasts sharply with the colors of the other growth on the surfaces of the cheese.

ISOLATION OF THE RED MOLD

Although the general appearance of the red colonies suggests that isolation of the mold would be simple, difficulties were encountered in the early attempts. Material taken from the colonies and smeared on various media usually gave such a heavy growth of bacteria, yeasts and *Penicillium roqueforti* that colonies of the red mold were not obtained. Eventually a cheese agar which had been developed for the isolation of *Bacterium linens* (1) was found to be fairly satisfactory.

To prepare the medium, 100 g. of ripened cheese is suspended in 300 ml. of distilled water containing 10 g. of potassium citrate. When the cheese is well distributed the mixture is warmed to about 50° C. and placed in a

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[1] Journal Paper No. 1153 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project 119.

cylinder for separation of the fat. Thirty minutes are enough to give reasonably complete separation. Only the aqueous portion of the suspension is used in the agar so the fat is removed by suction. Ten g. of peptone, 50 g. of sodium chloride, 2 g. of sodium oxalate and 15 g. of agar are dissolved in 700 ml. of distilled water. The cheese suspension is added to this mixture and the reaction is adjusted to pH 7.4. The agar is dispensed in bottles and sterilized in the autoclave for 25 minutes at 15 pounds pressure. When plates are to be poured, the melted and cooled agar must be thoroughly agitated to distribute the suspended cheese solids.

Material taken from the red colonies on cheese and smeared on the surface of the cheese agar regularly showed growth of various organisms but usually some areas were found on which the red mold was growing away from other species. By picking material from such areas and smearing on another cheese agar plate and repeating this procedure, pure cultures eventually were obtained, although a considerable period was required. Incubation of the plates at 18° to 21° C. with a relatively high humidity was satisfactory.

IDENTITY OF THE RED MOLD

Laboratory examination of the red mold disclosed it to be a fungus which has been known as a contaminant of cheese for many years. It grows very

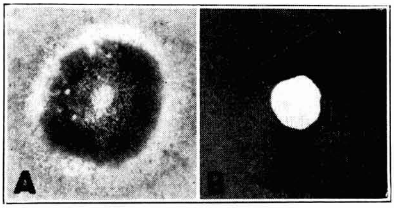

FIG. 1. Growth of *Sporendonema casei* on cheese agar (A) and potato dextrose agar (B) at 20° C., after 10 days.

slowly on the ordinary media used in mycological work, such as potato dextrose or Czapek's solution agar, but much more rapidly on the cheese medium mentioned above. This relationship explains the difficulty encountered when isolations were first attempted. On the cheese medium, the mycelium was floccose, white at first but soon becoming orange-red as the fruiting developed. On potato dextrose agar the growth was much slower, as is shown in figure 1 which illustrates colonies of the same age on the two media. On potato dextrose agar a further difference was noted; the red color was suppressed in the fungus but diffused into the medium turning it dark red. Optimum growth occured between 15° and 20° C.

Sporulation was initiated by the production of erect fruiting hyphae on the surface of a colony. These hyphae were club-shaped and sparingly branched, with septa at irregular intervals. They were two to three times the diameter of the mycelial threads that bore them (figure 2). Spores were laid down in the cells of the sporophores by the formation of thick walls within the walls of the sporophores. They were filled with oil drops which gave the characteristic color to the colonies. The spores were disc-shaped with rounded corners and were liberated by the breaking of the hyphal wall which surrounded them. They were variable in size depending on their position in the club-shaped fruiting hyphae; their longest diameter varied from 6 to 9 microns. These spores, being produced within the walls of the hyphae which bear them and also because of the thick wall, would be best denoted as chlamydospores, following the proposal of Vuillemin (17),[2] rather than conidia so that they would not be confused with similar thin-walled spores (arthrospores) produced on the hyphae of such fungi as

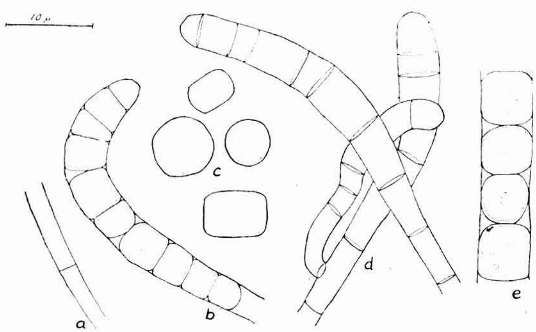

FIG. 2. Chlamydospores and sporophores of *Sporendonema casei*. a. Mycelium. b. Mature sporophore showing method of fracture. c. Mature conidia. d. Immature sporophores showing method of branching. e. Fragment of sporophore containing four mature chlamydospores.

Geotrichum candidum (*Oospora lactis*) as described by Langeron and Talice (8).

Taxonomically the name that should be used for the red mold is very difficult to determine. In 1826, Desmazières (6) described a red mold on cheese under the name of *Sporendonema casei* which he pointed out had been earlier denoted *Mucor crustaceus* Bulliard, *Aegerita crustacea* DeCandolle, *Oidium rubens* Link, and *Scpedonium caseorum* Link, but which did not fit into any of these genera because of the endogenous production of the spores, a character which had not been observed by earlier workers. Corda (5), in

[2] In 1910, Vuillemin (17) divided the asexual spore forms found in the Fungi Imperfecti into two main groups (a) *conidia vera, i.e.,* spores abstricted from the tip of a conidiophore and (b) *thallospores* which are part of the hypha bearing them. The thallospores were in turn divided into three types (a) *arthrospores* which arise by fragmentation of the hypha, (b) *blastospores* which arise as globular buds and (c) *chlamydospores*, thick-walled spores, laid down either terminally or intercalarily.

1838, denied the internal origin of the spores and transferred the fungus to his genus Torula and Saccardo (14), in 1880, emended the genus Oospora and, in 1882, included the red mold in it under the name *Oospora crustacea* (Bull.) Sacc. Since then this name has often been used for the organism. However, in 1924, Loubière (11) in his study of the molds found on cheese returned to *Sporendonema casei* as a designation for the red fungus. In the meantime the fungus and its name had been variously interpreted because of the lack of uniformity of usage among workers in this group of fungi. Berkhout (2), in her discussion of the molds in the group, treated it in a literature review under the name *Oospora crustacea.* Sumstine (15) stated: "The genus *Sporendonema* was first described by Desmazières with one species, *S. casei.* This is generally considered congeneric with the so-called *Oospora lactis* (Fres.) Sacc. and synonymous with *Oospora crustacea* (Bull.) Sacc." Unfortunately *Sporendonema casei* was not available to Sumstine for, had it been, he doubtless would have recognized the characters which remove it from Oospora or Oosporoidea, which latter genus he erected to receive *Oospora lactis,* and treated it in its proper place. Biourge (3) discussed the species in his monograph on the genus Penicillium among the species of the section Anomala but did not make a change of name. Thom (16) said of this culture: "There is no suggestion of relationship to Penicillium in this culture." Still more recently Linder (10), in his revision of the genus Oidium, suggested that his proposed usage of the name Oidium might clear the way "for accepting *Sporendonema* of Desmazière for those forms represented by *Oidium* or *Oospora lactis* and *casei,*" thus continuing to include *O. lactis* in the same genus with the cheese mold. In the meantime the name Sporendonema had been applied by Oudemans (12), in 1886, to another species, *S. terrestre,* by an emendation of Desmazières' description, a change accepted by Saccardo (14) and Lindau (9). Still later, in 1934, Ciferri and Redaelli (4) and Redaelli and Ciferri (13) again emended the genus to include certain fungi that were human pathogens. Dodge (7, p. 198) stated of Oudemans' fungus: "It does not seem related to Desmazières' original species" and that Ciferri and Redaelli "have used the name for wholly unrelated organisms."

The question of the name for the red cheese mold, then, becomes a question of the propriety of using Sporendonema or Oospora for this fungus, as well as one of the specific name. Oospora as a genus seems questionable (8) and certainly has not been considered to have endogenous spores, such as are found in the cheese mold. Further, the spores in that fungus are thick-walled chlamydospores rather than the thin-walled arthrospores characteristic of *O. lactis,* a species that has been suggested as congeneric. Hence Desmazières' name *Sporendonema* would seem to be the name to retain together with his specific name *casei* which was recognized by Fries. Such a procedure would mean a return to the Desmazières' genus and a discarding of the emendations thereof, and would clearly separate *Sporendonema casei* from *Oospora lactis,* a fungus that is not congeneric.

CONTROL OF THE RED MOLD

In some curing rooms in which the red mold is very conspicuous on the cheese surfaces, it appears to be difficult to control; at least, the plant operators believe this is the case and certainly the mold quickly develops on young cheese going into the rooms. In other curing rooms in which the red mold has been noted, but in which it has never been conspicuous, the mold appears to have been controlled by adequate cleaning of the cheese surfaces through scraping or washing. A factor that probably is of importance in this general connection is the period the cheese is in a curing room; with short curing there apparently is less chance for the mold to become thoroughly established in a room than with long curing.

A number of cheese were dipped in, or painted with, heated petrolatum to which calcium propionate and propionic acid had been added, the cheese first being dried as completely as possible by exposing them at room temperature to an electric fan. The mold inhibitors were used in different amounts and the petrolatum, which was said to melt at 55° to 58° C., was heated to 71°, 88° or 93° C. Considerable difficulty was encountered in getting a thin and uniform layer of petrolatum on the cheese and even at curing room temperatures the petrolatum remained soft and slipped when the cheese were handled.

The petrolatum tended to limit the surface growth on the cheese and most of the conspicuous growth was very near the punch holes which were made after the treatment with petrolatum. In general, it appeared that the petrolatum offered some interesting possibilities in preventing growth of the red mold and other organisms on cheese. However, a type of material which would be firmer than the petrolatum at curing room temperatures probably would be better.

SUMMARY

The red mold which develops on the surface of blue cheese in certain curing rooms was most easily isolated on a special cheese agar. Apparently the logical designation for the mold is *Sporendonema casei.*

Covering blue cheese with petrolatum containing mold inhibitors offers some interesting possibilities in preventing growth of the red mold on the cheese when the normal cleaning of the cheese does not.

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OBSERVATIONS ON THE USE OF ROLLER PROCESS SWEET CREAM BUTTERMILK POWDER IN ICE CREAM*

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INTRODUCTION

In recent years, the ice cream industry has used limited quantities of condensed and powdered sweet cream buttermilk as sources of milk solids-not-fat for ice cream. Whitaker (12), in 1936, reviewed the status of the use of sweet cream buttermilk in ice cream and considered the interest in this product as not being very great at that time. He noted that the ice cream manufacturer became interested in the use of the product when the price of skimmilk solids was high, or, in some localities, where the supply of sweet cream buttermilk was large. The demand for milk solids has been increasing at such a rapid pace that today the by-products of the dairy industry are being utilized as sources of human food to a much greater extent than ever before. In past years, the greater bulk of creamery buttermilk has been utilized as animal feed. Attempts are being made, however, to convert more of this by-product into channels of human consumption, and there has been a marked increase in the supply of this product in response to the sharp rise in demand for all forms of milk solids-not-fat. In those localities where concentrated sweet cream buttermilk products are available, many ice cream manufacturers are turning to these products as supplementary sources of milk solids.

REVIEW OF LITERATURE

Combs (3) was the first to report on the use of powdered sweet cream buttermilk in ice cream. From the results he obtained, using consumer preference tests, it appeared that ice cream which contained sweet cream buttermilk powder was considered equal, or slightly superior, to that which contained skimmilk powder as the source of milk solids-not-fat.

The use of sweet cream buttermilk has been found by some investigators to improve the whipping ability of ice cream mixes containing butter as the source of butterfat. Other investigators have reported less favorable results. Caulfield and Martin (2) concluded from their studies that there was no practical value in using powdered buttermilk as a means of improving the whipping ability of ice cream mixes; however, they observed a slight

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* Taken from data presented in a thesis submitted to the Graduate Faculty of the University of Minnesota by E. L. Thomas in partial fulfillment of the requirements for the degree of Master of Science. Scientific Journal Series Paper No. 2115, Minnesota Agricultural Experiment Station.

improvement. Tracy and Ruehe (9) concluded that no improvement in whipping ability resulted when buttermilk was used with butter in ice cream mixes. Whitaker (11) reported a saving of four minutes in the time required to reach the desired overrun when using buttermilk in a butter mix. The maximum overrun obtainable was also markedly increased over that of a butter and skimmilk control. He also noted that the buttermilk mixes showed less fat clumping than the control, and this phenomenon was accompanied with a lower basic viscosity. Whitaker believed that his findings suggested the presence of a material capable of stablizing the fat emulsion in the mixes containing buttermilk and stated that the material may be lecithin. Walts and Dahle (10) conducted an experiment which paralleled that of Whitaker. They found an average saving of two minutes in whipping time when buttermilk was used along with butter in ice cream mixes, as compared with similar mixes made with butter and skimmilk. They believed that the failure of butter mixes to whip as readily as cream mixes may be explained as due to the lack of the lecithin-protein complex and that the presence of this complex in relatively large amounts in the buttermilk may have been responsible for the results they obtained. Whitaker (12), in a discussion of the advantages of using buttermilk in ice cream called attention to its higher butterfat content in comparison with skimmilk, its superior emulsifying properties, and its ability to impart a rich creamy flavor.

EXPERIMENTAL METHODS

The data included in this report were obtained from studies dealing with the use of roller process sweet cream buttermilk powder as the additional source of milk solids-not-fat for ice cream. The experiments were conducted on a comparative basis and roller process skimmilk powder was used as the additional source of milk solids-not-fat for all control ice creams.

Method of obtaining the buttermilk and skimmilk products. Arrangements were made with a nearby Twin City plant to secure skimmilk and raw sweet cream which had been obtained from the separation of a single vat of mixed whole milk of high quality. The skimmilk was flash pasteurized at about 165° F. prior to its shipment. The cream was standardized to the desired butterfat content with a portion of the skimmilk from the same separation and was then pasteurized at 165° F. for 30 minutes, cooled to 40° F., and held overnight at this temperature before churning. A standard churning procedure was employed, and the buttermilk was recovered as soon as the butter granules were of proper size.

The skimmilk and sweet cream buttermilk were dried on a "Buflovak" atmospheric drum drier at the University of Minnesota creamery. In each trial, the fluid products were preheated to 155° F. before drying and were not precondensed. The operation of the drier was standardized before collecting the powder samples by first drying at least 200 pounds of the fluid skimmilk. After collecting the samples of powdered skimmilk, the buttermilk was dried immediately without interrupting the operation of the drier in order that both products could be obtained under similar operating conditions. All powders were analyzed for moisture, butterfat, and titratable acidity before use in ice cream mixes.

Method of processing and freezing the ice cream mixes. Eighty-five-pound mixes were prepared which had the following composition: 12.0 per cent butterfat, 11.0 per cent milk solids-not-fat, 15.0 per cent cane sugar, 0.30 to 0.35 per cent 225 Bloom gelatin, and 38.30 to 38.35 per cent total solids. All mixes were pasteurized at 160° F. for 30 minutes. The mixes were homogenized at the pasteurization temperature in a two-stage Colony homogenizer at pressures of 2,500 pounds and 500 pounds on the first and second stages, respectively. They were conducted directly from the homogenizer to a direct-expansion surface cooler and cooled to between 36° and 40° F. They were then aged at a temperature of 40° F. for a period of from 18 to 24 hours before freezing.

All mixes were frozen in a Creamery Package direct-expansion, batch freezer which had a capacity of 40 quarts. The batches were weighed accurately before being placed in the freezer and equal portions were prepared for freezing. Pure vanilla extract was added at the rate of 4 ounces per 40-pound batch.

Extreme care was taken to secure uniform freezing conditions when freezing a series of mixes in order that comparative freezing and whipping data could be obtained. A preliminary batch of mix was always frozen to chill the freezer and to standardize operating conditions. The time of freezing was standardized and was held constant for each series of mixes. All samples of ice cream used for meltdown tests and scoring were taken at an overrun of 90 per cent and placed immediately in a hardening room maintained at about – 10° F.

Methods of testing the ice mixes and ice cream. The total solids content was determined on all ice cream mixes according to the method outlined by Mojonnier and Troy (5).

The titratable acidity was determined on duplicate samples of each ice cream mix within 18 hours after processing. A 9-gram sample of undiluted mix was titrated with N/10 sodium hydroxide using phenolphthalein as the indicator. The acidity was calculated as per cent lactic acid.

The pH of the mixes was determined with a Coleman Model 3 Electrometer.

The original, apparent, and basic viscosities were determined on all mixes. The original viscosity was determined on a sample of the fresh mix immediately after cooling. The apparent and basic viscosities were those of the aged mix after an aging period of about 18 hours. A sample of unagitated mix was used for the apparent viscosity measurements, whereas the basic viscosity was that of a sample of the aged mix after it had been passed through a hand emulsifier operated at the rate of 78 strokes per minute, according to the method of Penczek and Dahlberg (6). The viscosities were determined with an Improved MacMichael viscosimeter operated at 20 revolutions per minute and using a standard disc plunger suspended by a number 31 wire. The wire was calibrated with a 60 per cent sucrose solution and all readings were converted to viscosity in centipoises. All viscosity readings were taken at a temperature of 40° F., and the operations were conducted in a room maintained at about 40° F.

All overrun determinations were made at the freezer by the use of a Mojonnier Overrun Tester. The tester was accurately calibrated for each batch of mix immediately before freezing.

A general indication of whipping ability was secured for all ice cream mixes by checking the time required to whip to an overrun of 90 per cent. In each case duplicate batches were frozen for an extended whipping ability test. The frozen mix was allowed to whip until the maximum overrun had been reached and the overrun and temperature of the ice cream were determind at one-minute intervals throughout the whipping process. Temperatures were determined with a sub-zero centigrade thermometer graduated in 0.1-degree divisions. The temperature in each case was estimated to the nearest 0.05 degree and all centigrade readings were converted to degrees Fahrenheit.

During one trial, Draw-Rite readings were recorded at minute intervals during the freezing and whipping of each mix and coincidently with each overrun determination. It was believed that since Draw-Rite readings serve as an indication of the consistency of the ice cream in the freezer, it would be possible to utilize these readings in comparing the consistencies of the ice cream throughout the freezing process.

The melting properties of the ice cream were determined by allowing a pint sample of ice cream to melt at room temperature. The ice cream (a weighed sample) was placed on a wire screen which had been placed over a glass funnel, and the drippings were collected in a beaker. The weight of drainage was determined at regular intervals until melting was nearly complete.

The ice creams were scored for flavor and body and texture by two experienced judges of dairy products. The age of the sample at each scoring was recorded along with the scores and criticisms.

RESULTS

Representative data from three experiments are included in this report. For purposes of discussion these experiments will be referred to as trials A, B, and C.

Trial A. For trial A, a series of four mixes was designed as follows:

Mix number	*Source of butterfat*	*Source of additional milk solids-not-fat*
1 (control)	cream	R.P.* skimmilk powder
2	cream	R.P. sweet cream buttermilk powder
3 (control)	unsalted butter	R.P. skimmilk powder
4	unsalted butter	R.P. sweet cream buttermilk powder

*Roller process.

The skimmilk and buttermilk powders were derived from the same lot of whole milk and supplied in each case about 46 per cent of the milk solids-

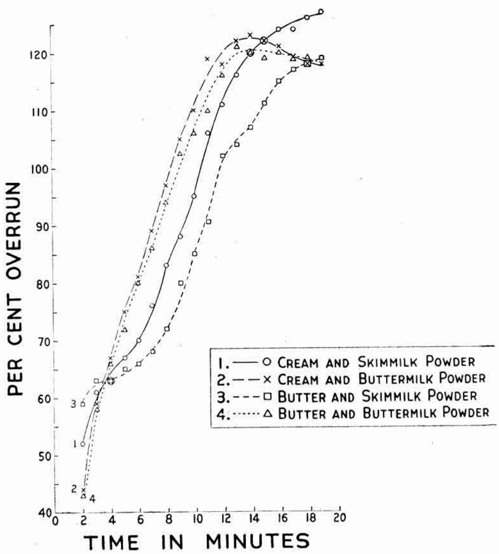

FIG. 1. The effect of roller process sweet cream buttermilk powder on the whipping ability of ice cream mixes containing cream and butter as sources of butterfat.

not-fat in the mix. Duplicate batches of each mix were frozen, and one batch was drawn at an overrun of 90 per cent, whereas the other batch was allowed to whip to the maximum overrun in order to obtain whipping ability data. The data obtained from the trial are presented in table 1 and figure 1. There were no marked differences among the viscosities of either the fresh or aged mixes in this trial. The most marked difference was evident in the rates of whipping of the mixes in the freezer. In each comparison (table 1) the mix which contained buttermilk powder attained an overrun of 90 per cent more rapidly than the skimmilk powder control, resulting in a saving in time of from about 2 to 3 minutes. In each case, it will be noted that the ice cream which contained buttermilk powder was drawn from the freezer at a lower temperature than the control. A more complete picture of the whipping ability of the mixes is presented in figure 1. It will be noted that there was an initial "lag" in the rate of overrun development in the early stages of whipping for each of the buttermilk mixes. The greatest maximum overrun was attained in the cream and skimmilk powder mix. In each case, the ice cream which contained buttermilk powder was firmer

TABLE 1

Trial A.—The effect of sweet cream buttermilk powder upon certain properties of ice cream mixes and ice cream containing either cream or butter as the source of butterfat

Properties of ice cream mix	Mix			
	1	2	3	4
	Cream and skimmilk powder	Cream and buttermilk powder	Butter and skimmilk powder	Butter and buttermilk powder
Titratable acidity (%)	0.190	0.190	0.195	0.195
pH	6.31	6.31	6.32	6.31
Original viscosity (centipoises)	34.5	35.5	34.8	35.3
Apparent viscosity (centipoises)	179.0	144.0	147.5	155.0
Basic viscosity (centipoises)	55.3	45.3	48.5	49.5
Freezing time (min.: sec.)	2: 0	2: 0	2: 0	2: 0
Whipping time (min.: sec.)	7: 5	4: 16	6: 55	4: 51
Final overrun (%)	90.0	90.0	90.0	90.0
Temperature when drawn (° F.)	24.44	23.81	24.44	23.99
Condition when drawn	Sl. soft, wet	Very firm, dry	Sl. soft, wet	Firm, sl. wet
Melting properties at 75° F.				
Per cent drainage				
After 60 minutes	23.6	25.3	29.7	25.4
" 90 minutes	56.8	57.0	63.9	54.7
" 120 minutes	74.2	77.7	84.3	76.6
Appearance of meltdown	Coarse foam	Fine foam	Coarse foam	Fine foam
Flavor scores and criticisms				
After one week	39.0 Lacks freshness, sl. cooked	38.5 Lacks freshness	39.0 Lacks freshness, sl. cooked	38.0 Lacks freshness
After four weeks	38.0 Stale	38.0 Stale	38.0 Stale	38.0 Stale
Body and texture scores and criticisms				
After one week	28.0 Coarse	29.0 Sl. coarse	28.0 Coarse	29.0 Sl. coarse
After four weeks	28.0 Coarse	28.5 Coarse	28.0 Coarse	28.5 Coarse

and drier in appearance when drawn from the freezer than the control. The results of the meltdown tests indicate that there were no marked differences in the rates of drainage from the melting samples. All samples were foamy, but the foam from the samples which contained buttermilk powder was noticeably finer in structure and more stable than that of the controls. The initial flavor scores of the ice cream samples which contained buttermilk powder were slightly less than the controls, but no differences were apparent after four weeks in storage. A cooked flavor was initially present in the samples which contained skimmilk powder, but this flavor was not detected in the other samples. The buttermilk ice creams were judged better in body and texture than the controls at both the initial and final scorings.

Trial B. It has been conclusively demonstrated by various investigators (1, 4, 7, 8) that as the butterfat content of the cream churned is increased there is an increase in the phospholipid content of the resulting buttermilk. Trial B was therefore designed to determine the influence of variations in the phospholipid content of sweet cream buttermilk powders upon the properties of ice cream mixes and the frozen products. Roller process sweet cream buttermilk powders were prepared from buttermilks obtained by the churning of three lots of sweet cream which contained 25, 33, and 40 per cent butterfat, respectively. The lower testing creams were obtained by standardizing portions of a single lot of 40 per cent cream with skimmilk from the same separation. A quantity of the skimmilk was dried for use in the control mixes. Four ice cream mixes were prepared from cream, skimmilk, and either skimmilk or buttermilk powder as follows:

Mix number	*Source of additional milk solids-not-fat*
1 (control)	R.P.* skimmilk powder
2	R.P. buttermilk powder from 25 per cent cream
3	R.P. buttermilk powder from 33 per cent cream
4	R.P. buttermilk powder from 40 per cent cream

* Roller process.

The data obtained from one set of mixes are presented in table 2, and the results of the whipping ability tests obtained from the freezing of duplicate batches are illustrated in figures 2 and 3. As shown in the table, the original, apparent, and basic viscosities were quite uniform for the entire series of mixes. Every mix which contained sweet cream buttermilk attained the desired overrun of 90 per cent in approximately 2 minutes less time than the control. An examination of the overrun-time curves of figure 2 reveals that the mixes attained practically the same maximum overrun. An initial lag in the overrun curves of the buttermilk mixes is clearly evident. The overrun-temperature relationships for each of the mixes are illustrated in figure 3. It is evident that the overruns of the mixes which contained sweet cream buttermilk powder were attained at a lower temepratu re than the control throughout the major part of the whipping process. As was found true in other trials, the freshly drawn ice creams which contained buttermilk powder were firmer and drier in appearance than the ice cream which contained skimmilk powder. The melting properties, flavor scores, and body and texture scores of the ice cream samples were quite uniform. The foam from the melting samples which contained buttermilk powder was finer in structure and more stable than that of the control sample. A cooked flavor was noted in the control sample but was absent in all other samples.

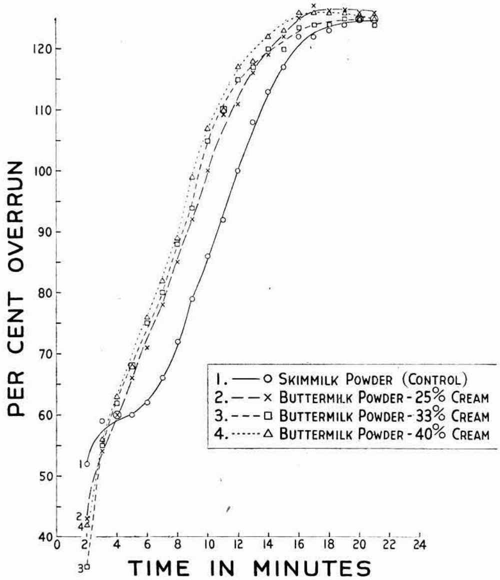

FIG. 2. The effect of roller process sweet cream buttermilk powders derived from creams of various butterfat contents on the whipping ability of ice cream mixes containing cream as the source of butterfat.

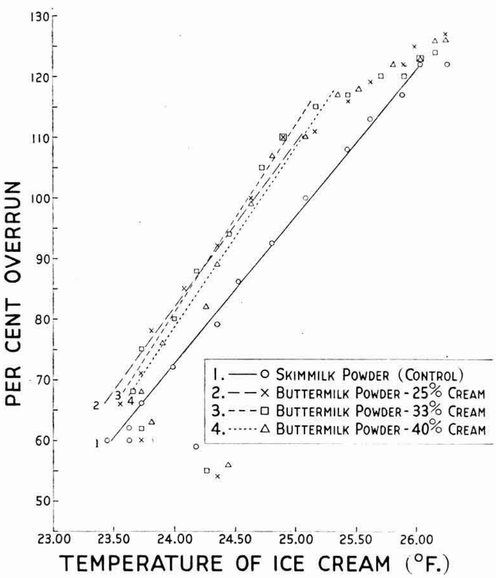

FIG. 3. The effect of roller process sweet cream buttermilk powders derived from creams of various butterfat contents on the overrun-temperature relationship of ice cream mixes.

Trial C. Trial C was conducted in exactly the same manner as trial B with the exception that butter was used as the source of butterfat instead of cream. The data presented in table 3 show that the results obtained practically paralleled those obtained in the previous trial. The viscosity data were more irregular, but the differences were not considered significant. It will be noted that the drainage from the melting ice cream samples which contained buttermilk powder tended to take place at a slower rate than that of the control. The overrun curves presented in figure 4 show that the greatest maximum overrun was attained in the control mix. The differences in rate of overrun development were not as pronounced as in trial B, but otherwise the same general relationships existed. The overrun-temperature

TABLE 2

Trial B.—The effect of sweet cream buttermilk powders derived from creams of various butterfat contents upon certain properties of ice cream and ice cream containing cream as the source of butterfat

Properties of ice cream mix	Mix			
	1	2	3	4
	Skimmilk powder	Buttermilk powder*	Buttermilk powder†	Buttermilk powder‡
Titratable acidity (%)	0.190	0.185	0.185	0.190
pH	6.42	6.41	6.42	6.42
Original viscosity (centipoises)	42.5	44.0	43.3	44.0
Apparent viscosity (centipoises)	127.5	122.0	122.3	116.5
Basic viscosity (centipoises)	44.3	47.0	45.0	45.5
Freezing time (min.: sec.)	2: 0	2: 0	2: 0	2: 0
Whipping time (min.: sec.)	7: 40	5: 55	5: 50	5: 26
Final overrun (%)	90.0	90.0	90.0	90.0
Temperature when drawn (° F.)	24.62	24.35	24.26	24.26
Condition when drawn	Firm, sl. wet	Firm, mod. dry	Firm, mod. dry	Very firm, mod. dry
Melting properties at 75° F.				
Per cent drainage				
After 60 mintues	19.4	20.1	21.7	19.2
" 90 minutes	49.6	50.0	51.8	47.6
" 120 minutes	69.4	71.3	73.1	71.7
Appearance of meltdown	Coarse foam	Fine foam	Fine foam	Fine foam
Flavor scores and criticisms				
After three days	40.0 Cooked	40.0	40.0	40.0 ....
After three weeks	40.0 Cooked	40.0	40.0	40.0 ....
Body and texture scores and criticisms				
After three days	29.0 Sl. coarse	29.0 Sl. coarse	29.0 Sl. coarse	29.0 Sl. coarse
After three weeks	28.5 Coarse	28.5 Coarse	28.5 Coarse	28.5 Coarse

* Derived from 25 per cent cream.
† Derived from 35 per cent cream.
‡ Derived from 40 per cent cream.

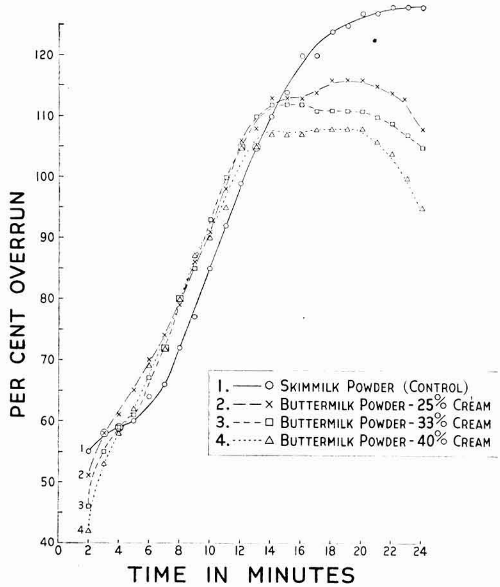

FIG. 4. The effect of roller process sweet cream buttermilk powders derived from creams of various butterfat contents on the whipping ability of ice cream mixes containing butter as the source of butterfat.

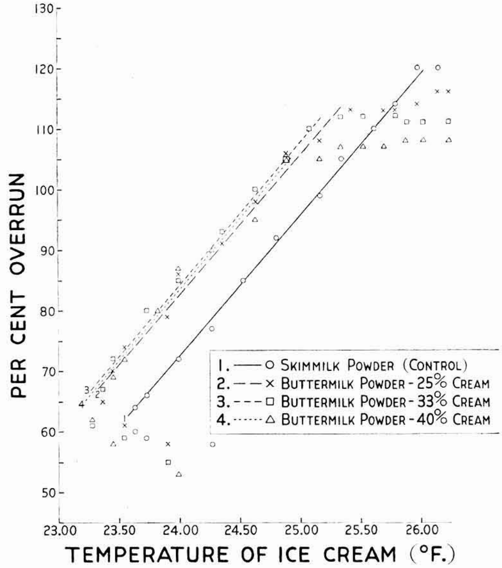

FIG. 5. The effect of roller process sweet cream buttermilk powders derived from creams of various butterfat contents on the overrun-temperature relationship of ice cream mixes containing butter as the source of butterfat.

relationships, illustrated in figure 5, show that the capacity to overrun at a given temperature was greater for the mixes which contained buttermilk powder than for the control throughout that part of the whipping process where a straight-line relationship existed. The use of Draw-Rite readings in comparing the consistencies of the ice creams throughout the freezing process served as evidence that each of the ice creams which contained sweet cream buttermilk powder was greater in consistency than the control throughout the major portion of the whipping period. The results are illustrated in figure 6.

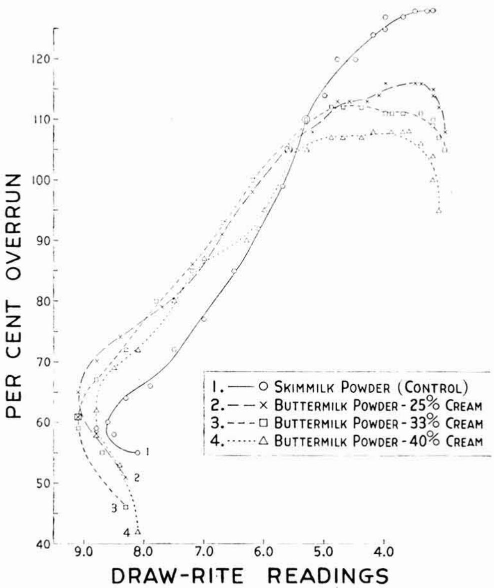

FIG. 6. The effect of roller process sweet cream buttermilk powders upon the consistency of ice cream mixes during the whipping process as measured by Draw-Rite readings.

SUMMARY

Experiments were conducted to determine the influence of roller process sweet cream buttermilk powder upon the properties of ice cream mixes and ice cream. The buttermilk product was used as the additional source of milk solids-not-fat for ice cream and the corresponding skimmilk product was used in the same manner in control mixes. In every comparison, the sweet cream buttermilk and skimmilk products were both derived from the same lot of mixed whole milk.

There were no consistent or marked differences in the viscosities of the ice cream mixes which could be attributed to any single factor.

TABLE 3

Trial C.—The effect of sweet cream buttermilk powders derived from creams of various butterfat contents upon certain properties of ice cream mixes and ice cream containing butter as the source of butterfat

Properties of ice cream mix	Mix 1	Mix 2	Mix 3	Mix 4
	Skimmilk powder	Buttermilk powder*	Buttermilk powder†	Buttermilk powder‡
Titratable acidity (%)	0.200	0.190	0.190	0.190
pH	6.35	6.33	6.34	6.34
Original viscosity (centipoises)	42.5	40.8	40.0	39.3
Apparent viscosity (centipoises)	133.0	160.5	118.5	105.5
Basic viscosity (centipoises)	52.0	45.0	44.0	40.5
Freezing time (min.: sec.)	2: 0	2: 0	2: 0	2: 0
Whipping time (min.: sec.)	8: 10	6: 45	6: 46	6: 0
Final overrun (%)	90.0	90.0	90.0	90.0
Temperature when drawn (° F.)	24.62	24.17	24.08	23.99
Condition when drawn	Sl. soft, wet	Mod. firm, mod. dry	Very firm, dry	Very firm, dry
Melting properties at 78° F.				
Per cent drainage				
After 60 minutes	43.4	34.1	32.8	38.1
" 90 minutes	72.3	61.8	59.9	61.9
" 120 minutes	92.4	85.5	84.2	84.6
Appearance of meltdown	Coarse foam	Fine foam	Fine foam	Fine foam
Flavor scores and criticisms				
After four days	39.5 Lacks freshness, cooked	39.5 Lacks freshness	39.5 Lacks freshness	39.5 Lacks freshness
After three weeks	38.5 Sl. cooked, lacks freshness	39.0 Lacks freshness	39.0 Lacks freshness	39.0 Lacks freshness
Body and texture scores and criticisms				
After four days	29.0 Sl. coarse	29.0 Sl. coarse	29.0 Sl. coarse	29.0 Sl. coarse
After three weeks	28.0 Coarse	28.0 Coarse	28.0 Coarse	28.0 Coarse

* Derived from 25 per cent cream.
† Derived from 33 per cent cream.
‡ Derived from 40 per cent cream.

A consistent improvement in the whipping ability of ice cream mixes was obtained through the use of roller process sweet cream buttermilk powder as the additional source of milk solids-not-fat in place of skimmilk powder. In most trials, the desired overrun was obtained in one to two minutes less time than for the control mixes. The superior whipping ability of the mixes which contained roller process sweet cream buttermilk powder was further evidenced by the fact that the desired overrun was obtained at a lower temperature than that of the controls. Overrun-time curves and overrun-temperature curves derived from whipping tests are presented which show that the superior whipping ability of sweet cream buttermilk mixes persisted over a wide range of overruns. The maximum overrun obtainable was not increased through the use of roller process sweet cream buttermilk powder and tended to be somewhat inhibited in butter mixes.

Ice creams which contained sweet cream buttermilk solids were observed to be drier in appearance and greater in consistency when freshly drawn from the freezer than control mixes which contained skimmilk solids.

The melting resistance of the ice creams was not markedly affected by the use of sweet cream buttermilk solids. In all comparisons, it was noted that the ice creams which contained sweet cream buttermilk solids were more foamy in appearance during melting and that the foam of the filtrate contained smaller air cells than that of the control samples.

In many comparisons, the samples of ice cream which contained sweet cream buttermilk solids were judged as richer in flavor than the controls which contained skimmilk powder. It was further noted that whereas ice cream which contained roller process skimmilk powder was often criticized for possessing a cooked flavor, this criticism was never employed in evaluating the ice creams which contained roller process sweet cream buttermilk powder.

The use of roller process sweet cream buttermilk powders derived from buttermilk obtained by the churning of sweet cream testing either 25, 33, or 40 per cent butterfat was found to influence the ice cream mixes in a similar manner. In view of these results, it appears that the normal variations in the phospholipid content of buttermilk which result from the churning of creams within the above range of butterfat contents have no significant influence upon the properties of either ice cream mixes or ice cream, the maximum effect being approached through the use of buttermilk from 25 per cent cream.

CONCLUSIONS

The following conclusions are believed justified after a careful analysis of all observations relative to the experimental work reported above:

1. Neither the original viscosity nor the apparent and basic viscosities of the aged mix are significantly affected when using roller process sweet cream buttermilk powder in place of roller process skimmilk powder as the source of additional milk solids-not-fat for ice cream.

2. The use of roller process sweet cream buttermilk powder in ice cream mixes results in a greater rate of whipping than when using roller process skimmilk powder. Usually, 1 to 2 minutes less time is required to obtain a normal overrun, and the overrun is attained at a lower temperature. This is true when either cream or unsalted butter is used as the source of butterfat for the mix.

3. The use of roller process sweet cream buttermilk powder in ice cream results in a freshly frozen product which is drier in appearance and greater in consistency than when the skimmilk product is used.

4. Roller process sweet cream buttermilk powder tends to impart a richer flavor to ice cream than roller process skimmilk powder.

5. There is less tendency toward a cooked flavor in ice cream containing roller process sweet cream buttermilk powder than when containing the skimmilk product.

6. Ice cream containing roller process sweet cream buttermilk powder is characterized by a foamy meltdown, the foam being finer in structure and more stable than that of ice cream containing roller process skimmilk powder.

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THE ACTION OF THE MECHANICAL MILKER IN RELATION TO COMPLETENESS OF MILKING AND UDDER INJURY[1]

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Although many are convinced that mechanical milking can be as good or better than hand milking, two major objections to machine milking are raised by some. One objection is that the mechanical milker causes injury to the teats and udder and the other is a claim that many cows will not milk out completely by the machine, necessitating milking varying amounts by hand.

The question as to whether or not the mechanical milker can cause injury to the teat and udder is an important one. It is common knowledge that trauma to the teat and udder, that is readily detected, is followed by a high incidence of clinical mastitis. Evidence is accumulating to indicate that trauma to the inner linings of the teat and gland, not detectable by palpation, may be an important predisposing factor to mastitis infection. Kennedy (3) has reported that by careful daily examinations of the teats and udder he detected trauma in varying degrees before the mastitis organism could be found in the milk.

It is well known that some cows do not milk out completely to the machine, as it is ordinarily operated. Sometimes as much as 40 per cent or more of the milk in the udder is removed by hand milking after removal of the machine. It is commonly observed that incomplete milking by the machine is more common among older cows than among first-calf heifers. It is obvious that much of the advantage of machine milking is lost when it becomes necessary to remove varying amounts of milk by hand milking.

THE PROBLEMS AND METHODS OF STUDY

Since a search of the literature failed to reveal any reports (except Petersen, 3) dealing specifically with either of these problems, work was instituted with a view of obtaining information toward their solution. Attempts were also made to compare the force exerted by the mechanical milker with that of hand milking.

To determine the action of the milking machine upon the udder a technique was developed whereby the excised mammary gland is used. The actual rate and completeness of milking by machine was ascertained on a number of cows by suspending the milking machine from a scale from which readings were taken every 20 seconds.

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The excised udder was suspended in the laboratory in approximately the normal position, by means of hooks in the median suspensory ligament and lateral facia. The gland cisterns were cannulated with glass cannula with a bore of 8 mm. or more. Skimmilk or physiological saline was then infused by gravity so as to maintain an intra-sinus pressure of approximately 50 mm. Hg. This is about the pressure developed in the cistern by the let down of milk. Skimmilk has been found more satisfactory than physiological saline as the latter will cause varying amounts of edema over a period of time.

Since the tonicity of the sphincter muscles surrounding the meatus of the teat is well maintained in the excised gland this preparation lends itself well to a study of mechanical milking. Observations have been made on the effect of such variables as pulsation rate, different vacuum levels, variations in size, shape and condition of the rubber inflations and others. Results of these observations will be presented in a later paper.

The most striking suitability of this preparation, however, was in the study of the action of the milking machine upon the teat and udder. After the gland had been filled with fluid through the inserted cannula the position of the teat cup on the teat could be observed with varying intra-sinus pressures, as could also the rate of milk withdrawal. The rate of inflow was regulated by adjustment of screw clamps on the rubber tubing connecting the skimmilk or physiological saline reservoir with the cannula in the sinus.

The action of the mechanical milker upon the inside of the teat and gland sinus was observed through incisions made in the lateral wall of the sinus or through a 2-inch tube inserted in an incision made perpendicularly over the orifice between the gland sinus and the teat. From the lateral incision the action could be felt by the insertion of a finger and actual measurements of the amount of suction developed within the teat were made by means of a vacuum gauge.

The force or "massage" action of the collapse of the rubber inflation upon the teat upon release of vacuum in the teat cup shell was also measured by the insertion of a small rubber bulb, attached to a manometer, into the teat sinus.

All of the observations reported herein were made by the use of double action mechanical milkers.

The measurements of the force applied to the teat in hand milking was accomplished both on the excised gland and on cows. In the excised gland this measurement was obtained by inserting a small rubber bulb attached to a mercury manometer into the teat sinus and different experienced milkers were used. The measurements on cows were taken with the same instrument, the rubber bulb being held in the palm of the hand so that pressure on the teat would cause compression thereof.

After a number of trials it was found that a rubber bulb of $2\frac{1}{2}$ cc. capacity was the most satisfactory. This size held the minimum amount of mercury

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needed and at the same time offered less interference to milking than larger bulbs. The bore of the manometer was such that it held 1 cc. mercury per 20 inches.

RESULTS

When the intra-gland sinus pressure remained constant in the excised gland the rate of milk withdrawal by the machine was constant for any given vacuum. With reduced intra-gland sinus pressures, the effect upon the rate of milk withdrawal varied with different glands. In some cases the rate of milk withdrawal began decreasing with a drop to 30 mm. Hg pressure and in others no detectable change was noted, until the intra-sinus pressure dropped to 10 mm. Hg or less. At the time that the rate of milk withdrawal began to decline the teat cups were noted to crawl upwards (C, fig. 1) with each vacuum stroke. The rates of crawling and decrease in milk withdrawal varied with different glands. In general it was noted that the rate of decline of milk withdrawal was more rapid when the crawling was also more rapid.

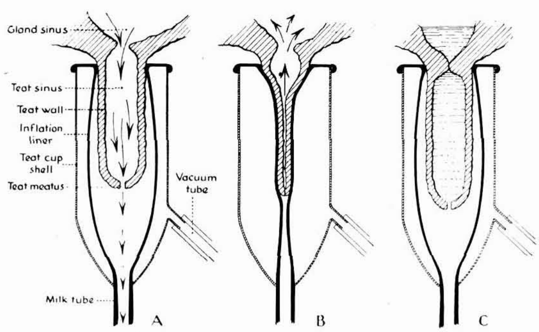

FIG. 1. Illustration of the action of the mechanical milker upon the teat. A. Vacuum applied in teat cup shell when the gland is full of milk. The teat meatus is opened and milk streams through it. B. Release of vacuum in the teat cup shell. The teat meatus is closed and a part of the milk in the teat sinus is forced back as a result of compression of the teat caused by the collapse of the inflation liner. C. Teat cup has crawled upward. The orifice between the gland and teat sinus is closed preventing passage of milk into the teat.

In 12 out of 14 cases the milk flow stopped before the gland was completely evacuated even though the machine was left attached. In all cases the gland was completely evacuated when the teat cups were pulled down part way on the teat. Once the teat cups had been permitted to crawl upward to a point where milk withdrawal had stopped it was necessary to increase the intra-gland sinus pressure by inflow of fluid to a point greater than that which would prevent the teat cup from crawling before milk withdrawal would again begin without a downward pull on the teat cups. While these values varied for different glands representative values lie between 10 and 20 mm. Hg greater pressure required to resume milk flow than is necessary to prevent the teat cups from crawling.

The reason for the teat cups crawling and the ultimate complete stoppage of milk withdrawal when the intra-sinus pressure is sufficiently reduced is seen through an incision through the sinus wall. By inserting the finger it was possible to ascertain that when the intra-gland sinus pressures were sufficiently high the orifice between this sinus and that of the teat remained wide open at all times as illustrated in A and B in figure 1. Under these conditions there is no restriction to the milk flow downward through the teat meatus upon the application of vacuum. It could also be felt that upon release from vacuum a small but definite spurt of milk flowed from the teat into the gland sinus as the result of compression of the rubber inflation upon the teat (B, fig. 1).

When the teat cups began to crawl upward as the result of reduced intra-gland sinus pressures the orifice could be felt to close. In most cases even though the gland sinus was filled with milk the closure was complete. In five instances free incisions were made so that the gland sinus communicated with the atmosphere without any air being drawn into the teat. If after the orifice between the gland and teat sinus is closed the teat cup is lowered part way down on the teat it was again opened.

Through the tube inserted perpendicularly through the gland the action of the pulsations on the tissues could be observed. It was noted that with each vacuum stroke the soft tissues surrounding the juncture of the gland and teat sinus were not only brought forcibly together but were also vigorously forced downward.

No detectable vacuum is developed in the teat as the result of milking machine action until there is partial closure of the orifice between the gland sinus and the teat. When the orifice is completely closed the vacuum within the teat sinus is the same as that in the milk line. With each release of vacuum in the shell of the teat cups the vacuum disappears within the teat because of the collapse of the rubber inflation compressing the teat.

It is difficult to obtain accurate measurements of the force exerted upon the teat by the collapse of the rubber inflation caused by the release from vacuum in the teat cup shell. The hammer-like force of the collapse has a tendency to cause the mercury, in the case of the mercury manometer, or the needle in the case of an air pressure gauge to overshoot. The values as observed are therefore only approximate. That there is a definite massaging action is certain. The approximate force is from 25 to 60 mm. Hg. Variations in the amount of force exerted were observed between different inflations of the same type, the reasons for which are obscure.

In a subsequent report factors affecting the speed of milking will be dealt with in more detail. Here will be presented only those observations on milking by machine that contribute directly to the action of the machine. In figure 2 is presented the results of milking a cow, first with the machine left on until no more milk was obtained, then followed by hand milking and secondly, when the teat cups were drawn part way down at the time the rate of withdrawal began to decrease. It will be noted that the rate of milk withdrawal was constant for the first 2 minutes after which it decreased rapidly, with no manipulation of the machine, stopping completely in about 4½ minutes. After removal of the machine 2.1 pounds of milk were obtained by hand milking. When the teat cups were pulled partly down on the teats the rate of withdrawal did not begin to decrease until after 2 minutes, 40 seconds, and the gland was completely emptied without hand milking in 3 minutes.

Without going into detail it must be stated that great variation exists between different cows in the type of curve presented by plotting rates of

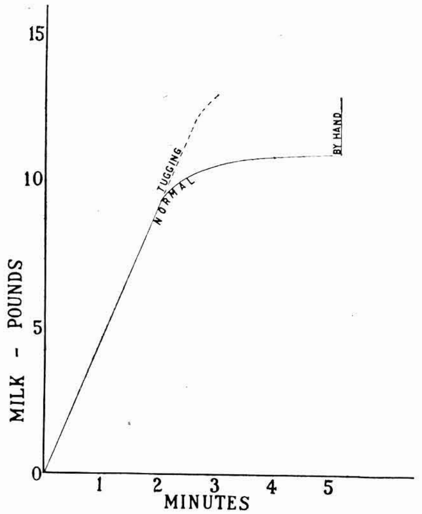

FIG. 2. Illustration of the effect of tugging upon the teat cups, when they begin to crawl, upon the rate and completeness of milking.

milk withdrawal by machine. So far, however, no cow in the University herd cannot be completely milked out by machine. For the majority of cows it is necessary to draw the teat cups downward to effect a complete evacuation of all of the milk in the gland.

The attempts at determining the force exerted upon the teat in hand milking was found to be difficult and not too satisfactory. The presence of the rubber bulb either in the teat sinus, in the excised gland, or in the palm of the hand in natural milking undoubtedly contributed to changes in the force applied. The inertia of the mercury is another factor contributing to error in the results that must not be overlooked. The values observed, therefore, must not be taken as absolute but merely indicative of the force exerted.

Measurements taken on four milkers varied from 16 inches to 24 inches of Hg pressure on the same cow. One fast milker exerted as much as 32 inches of Hg pressure in milking a hard-milking cow.

DISCUSSION OF RESULTS

The observations on the action of the mechanical milker upon the teat and udder in relation to varying intra-gland sinus pressures explains the observed curve characteristics when the rate of milk withdrawal is plotted. It is also in accordance with what would be expected on the basis of known physical laws. As all of the observations reported herein were made on the double action mechanical milker there is a continuous vacuum on the milk tube and alternate vacuum and release in the teat cup shell. The application of vacuum in the teat cup shell draws the rubber inflations toward the teat cup walls, permitting the full force of the continuous vacuum in the milk line to act upon the teat. Since this force is exerted equally in all directions, there is a tendency for the teat to be pulled down into the teat cup. This pulling down of the teat and lower part of the udder is inhibited by two other factors—the rigidity of the tissues as a result of the pressure of the milk within the gland and a partial displacement of the void by the outrushing milk through the meatus.

As milk withdrawal progresses the intra-glandular pressure is reduced and the tissues offer less resistance to the sucking action and are thus drawn farther into the teat cup. As the tissues at the juncture of the teat and gland sinuses are drawn into the teat cup the orifice between the two becomes occluded and further flow of milk from the gland is first decreased and finally completely stopped. When this occurs it is obvious that the full force of the vacuum is applied to the drawing in of the teat and lower part of the udder. Since the teat meatus is opened it is to be expected, as was found, that the vacuum within the teat is identical with that in the milk line.

In comparing the force of mechanical and hand milking it is significant that normal good hand-milkers exert a greater force upon the teat than does mechanical milking with the usual vacuum. Also that the force exerted in hand milking is continuous throughout the entire milking process while in mechanical milking there is no measurable force exerted on the inside of the teat until the rate of milk withdrawal is reduced or completely stopped. It is possible that mechanical milking may have a greater traumatizing effect because of a somewhat shearing action than the straight compression action of hand milking. However, it is possible to so manage milking by machine, by removing it when free flow of milk ceases, that less injurious action will result to the teat and udder than with hand milking. On the other hand, if the machine is left on for prolonged periods after milk ceases to flow it can be injurious.

A well-established but little-recognized anatomical fact is the location of accessory secreting glands (4) in the gland sinus and in the upper part of the teat sinus. These accessory glands have but a single layer of columnar epithelial cells as contrasted to the two layers of pavement epithelium lining the major portion of the teat sinus and are therefore more easily injured. The greatest compression in hand milking, particularly, in stripping and the most vigorous action of the milking machine is on this vulnerable area.

Upon the release from vacuum the rubber inflation collapses to mildly compress the teat and thus help prevent congestion. Before the teat is compressed the meatus closes leaving the teat sinus full of milk. Any further compression on the teat causes milk to be forced upward into the gland sinus. Since the compression of the teat is not complete not all of the milk in the teat sinus is forced back.

Variations in the point at which the teat cups begin crawling and in the amounts of milk left in the gland after milk withdrawal (without force applied to the teat cups) can tentatively be explained on an anatomical basis. Where the anatomical structure is such as to offer greater resistance to being drawn into the teat cup it is obvious that milking will be more complete before there is occlusion between the teat and gland sinuses. Great differences have been observed in the extent of the annular ring at the juncture of the teat with the gland sinus. In some cases this annular ring may extend more than half way across the orifice from one side to conceivably help cause an earlier occlusion during milking.

The observation that once the teat cups have crawled upwards to occlude passage from the gland sinus to the teat considerable increase in intra-gland sinus pressure is needed to again resume milk withdrawal explains in part why more rapid milking is obtained when the cow has been stimulated to let down milk before milking. Another factor is that unless let down has taken place the gland sinuses are emptied and the machine is acting for varying lengths of time without removing any milk before they are again filled. Ely and Petersen (1) reported that about 45 seconds intervened between the secretion of the hormone responsible for the let down of milk and the actual let down. In practice, therefore, it is suggested that the stimulation for the let down should take place about one minute before attaching the mechanical milker.

SUMMARY AND CONCLUSIONS

1. A technique is described whereby the excised udder may be used in the study of milking by mechanical means and results of observations of the action of the mechanical milker on both excised and intact glands are reported.

2. When milk flows freely from the gland sinus into the teat there is no detectable vacuum created within the teat sinus.

3. When the intra-glandular pressure is sufficiently reduced the tissues become more flaccid and the teat cups crawl upward to cause a complete

closure of the orifice between the teat and gland sinuses. This fact accounts for the reported incomplete milking of some cows by machine.

4. Tugging upon the teat cups, when they begin to crawl, with sufficient force to bring them part way down on the teats will prevent closure of the passage and permits complete evacuation of all of the milk in the gland without resorting to hand milking.

5. When the teat cups have crawled upward to close the passage from the gland sinus to the teat the vacuum within the teat becomes identical to that in the milk line. It is postulated that this will have a traumatizing action upon the tissues being compressed. Attention is directed to the location of accessory secreting glands in the gland sinus and often in the upper part of the teat sinus. These are easily injured which predisposes to mastitis.

6. Good hand milkers apply a greater force to the teat with each squeeze than does the milking machine at ordinary recommended vacuums.

7. Observations of the action of the milking machine upon the teat and udder explains why milking speed is increased by stimulating the cow to let down milk before the milking is started.

8. It is concluded that when the mechanical milker is properly operated, especially removed as soon as the milk ceases flowing there is less danger of injury to the teat and udder than from hand milking.

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THE EFFECT OF THYROIDECTOMY ON LACTATION IN THE BOVINE[1]

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Although the galactopoietic effect of thyroxine or dried thyroid gland is well established, reports on the effects of thyroidectomy are conflicting. A significant decrease in the milk yield of thyroidectomized goats was reported by Grimmer (5) and Trautman (14), while Hibbs *et al.* (6) obtained lactation for more than a year following thyroidectomy. Nelson and Tobin (11) and Nelson (10) have reported obtaining no evidence that lactation in thyroprived rats were impaired, while Folley (2) observed marked diminution of milk secretion and subnormal subsequent lactations. More recently Preheim (12) found only a slight decrease in lactation in the thyroidectomized rat, while Karnofsky (7) reported a marked reduction. For lactating cows, Graham (4) observed a slight decrease in milk production following thyroidectomy.

In view, therefore, of the conflicting reports of various workers, investigations were undertaken to obtain additional information regarding effects of thyroidectomy on lactation.

PROCEDURE

Four grade Holstein females were selected for experimental subjects. Table 1 shows the age and previous history of each animal at the time of thyroidectomy.

TABLE 1
Experimental animals at time of thyroidectomy

Animal No.	Age (months)	History
A26	13	Virgin
A23	16	46th day, 1st gestation
A15	36	12th day, 2nd lactation
E294	45	7th day, 2nd lactation

In order to assure complete removal of the thyroid, exploratory operations were performed on A26 and A23 ninety days after the initial operation. Autopsy examinations confirmed complete thyroidectomy of E294 and revealed incomplete removal from A15. Blood analysis, general appearance and behavior also indicated that A15 retained some functional thyroid tissue throughout the experimental period.

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Parathyroid tissue embedded in the thyroid was unavoidably removed; however, the accessory parathyroids were left intact. No effort was made to determine the extent of the remaining functional parathyroid tissue.

Environmental factors such as care, management, housing and feeding were minimized to some extent by maintaining the experimental animals under the same conditions as the regular dairy herd.

Daily milk yield was recorded and samples taken for analytical purposes at 14 day intervals insofar as conditions would permit. These samples were analyzed for fat, total nitrogen, casein nitrogen, lactose and specific gravity.

RESULTS

The effects of incomplete and complete thyroidectomy on milk yield, fat yield and milk composition were studied. Data were accumulated on six lactations of four cows thyroidectomized at various stages of gestation and lactation.

Incomplete thyroidectomy. As shown in table 1 the thyroid glands were partially removed from A15 on the twelfth day of her first lactation period.

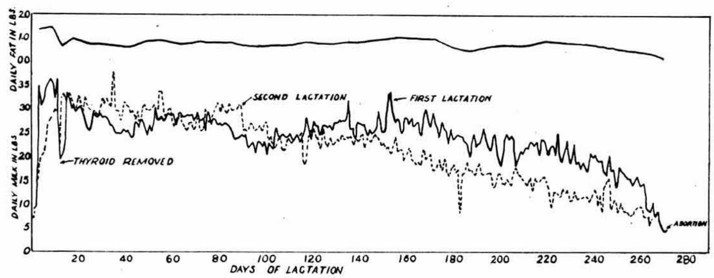

FIG. 1. Daily milk and fat yield of A15 following incomplete thyroidectomy on 12th day of first lactation. Second lactation began following abortion on 270th day of first lactation.

It is difficult to draw conclusions regarding the effects of incomplete thyroidectomy in view of the absence of previous lactations of A15 upon which to base a comparison. However, examination of the data presented in figure 1 reveals a distinct fall in milk production for 35 days following thyroidectomy, followed by a gradual upward trend of the curve of secretion. This response is undoubtedly explained, at least in part, by hypertrophy and hyperplasia of the remaining thyroid tissue which developed following the operation. The influence of thyroid hypertrophy is noticeably absent during the second lactation beginning after an abortion on the 270th day of the first lactation.

Milk yield. A comparison of the curves of milk secretion preceding and after thyroidectomy of E294, as shown in figure 2, clearly indicates the effects of thyroid ablation on milk yield. The point of maximum daily milk production was reached about 14 days previous to that of the normal lactation.

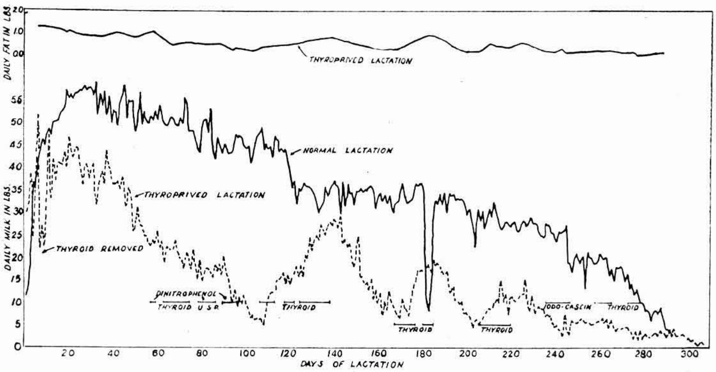

FIG. 2. Daily milk and fat yields of E294 for the lactation preceding thyroidectomy, for the subsequent thyroprived lactation, and during periods of thyrotherapy designated by ——. Daily fat yields for prethyroprived lactation unavailable.

Milk secretion practically ceased after about 110 days while total milk yield was reduced about 70 per cent as compared to the previous lactations.

Milk secretion as affected by thyroidectomy during pregnancy is presented in figure 3. As shown in table 1, cow A23 was thyroidectomized on the 46th day of her first gestation which was of normal term. Unfortunately, two outbreaks of mastitis occurred during the lactation period; however, the general trend of the milk yield curve was not significantly altered. Daily milk production dropped to a low level after about 110 days and ceased entirely 183 days after parturition.

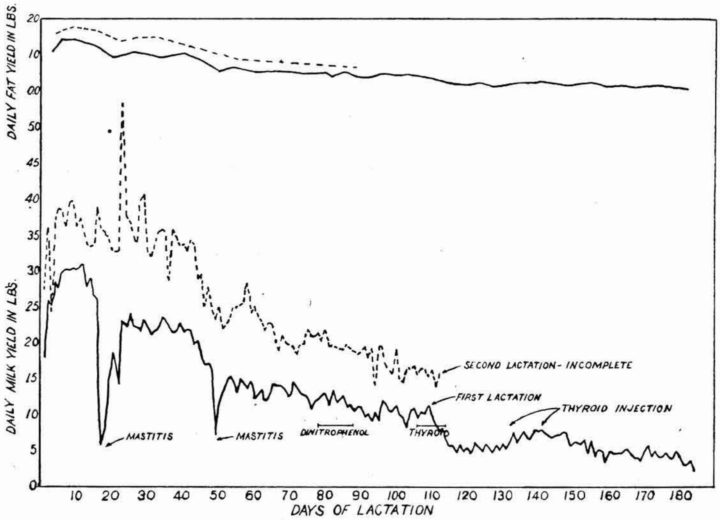

FIG. 3. First and second lactation milk secretion curves of A23 following thyroidectomy on 46th day of first gestation period.

Figures 1, 3, and 4 show the effects on milk secretion produced by removal of the thyroid glands before conception. The second lactation of A15 has been discussed. As shown in figure 3, A23 began her second lactation 720 days after thyroidectomy. A comparison of the second lactation and the preceding lactation indicates a higher level of secretion; however, the general trend of the curves is the same. Increased mammary development due to the beneficial effects of thyroid hormone or other factors from the developing fetus may account, at least in part, for the higher level of secretion observed during the second lactation. In this connection it is of interest to point out that a marked increase in skeletal growth of A23 was observed during the latter half of the preceding gestation period.

Figure 4 presents the milk secretion curve of A26 beginning 521 days after thyroidectomy. The curve of milk secretion is of normal shape; how-

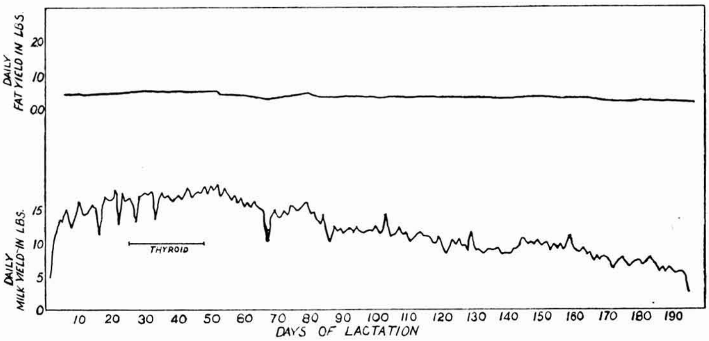

FIG. 4. Milk secretion curve of A26 beginning 521 days after thyroidectomy.

ever, lactation ceased 195 days after parturition. Although it is impossible to draw definite conclusions regarding the magnitude of the effects of thyroidectomy without previous knowledge of the producing ability of A26, it is significant that mammary development and milk secretion was possible some 521 days after thyroid removal.

Fat yield. The absence of more complete data on the daily production of milk fat precludes forming definite conclusions regarding the effects of thyroidectomy. It is, however, of interest to point out that based on the data obtained, the general trends and variations in fat yield were similar to those of milk yield.

Composition of milk. No significant changes in the lactose, total nitrogen and casein nitrogen content or specific gravity of the milk was evident from the results of periodical analyses. Values obtained for these constituents were all within the range for normal milk.

THYROTHERAPY

In view of the uniform decline of milk secretion observed after thyroidectomy, post-operative replacement therapy, in order to determine whether or not some unknown non-endocrine factor was involved, seemed to be indicated.

Dinitrophenol. Dinitrophenol, administered orally to two thyroidectomized cows produced a variable response in milk and fat yield. Oral administration of 5 grams of dinitrophenol per day to A23 for 11 days beginning on the 78th day of lactation as indicated in figure 3 failed to evoke a response in milk secretion. The response of E294 to dinitrophenol administration was only slightly dissimilar, as shown in figure 2. During the period from the 78th day to the 87th day, 28 grams were orally administered producing an increase in milk yield of about four pounds per day. However, during the next period from the 89th to the 98th day, when 3.5 grams per day were administered, daily milk yield dropped from 16.6 to 9.5 pounds. As no calorimeter was available the relationship between metabolic rate, milk secretion and dinitrophenol adminstration is not known.

Thyroid. Fresh frozen thyroid glands were obtained from a local abattoir, mixed in a meat chopper, placed in gelatin capsules and administered orally. Desiccated thyroid, U.S.P. XI, was administered in two instances.

In order to ascertain whether or not thyroid deficiency was the sole limiting factor of maximum daily milk yield, 200 grams of thyroid were administered per day to A26 for 15 days beginning on the 23rd day of lactation. As indicated in figure 4, the response was negligible. This may be partially ascribed to progressive impairment of the normal physiological processes resulting in loss of ability to respond to thyroid therapy, as 546 days had elapsed since thyroidectomy.

Interpretation of results of thyroid therapy in the case of A23, figure 3, was complicated due to the presence of chronic mastitis.

The results of oral administration of fresh thyroid on milk and milk fat secretion are strikingly illustrated in figure 2. Fresh thyroid administered to E294 during six different periods, beginning on 106, 167, 198, 258, and 273 days of the lactation period, elicited a decreasing response with each trial until the increase in milk and milk fat yield was barely evident.

Iodinated casein. Turner (15) has presented evidence of the lactation-stimulating properties of iodinated casein. It was believed the availability of thyroidectomized cows presented an opportunity for testing the efficacy of this preparation. On the basis of response to previous administration of fresh thyroid, E294 possessed the ability to yield 12 to 14 pounds of milk per day. Oral administration of 3000 grams of iodinated casein over a period of 12 days resulted in only a slight increase in milk and milk fat yield. However, subsequent oral thyroid therapy failed to evoke a response; therefore, conclusions cannot be drawn regarding the lactation stimulating properties of iodinated casein.

In seeking an explanation for the decreasing response to thyrotherapy, progressive involution of the mammary gland with advancing lactation must be considered. However, other factors may be involved, as involution of the mammary gland cannot account for the drastic decline and almost complete cessation of lactation 110 days after calving. Progressive impairment of normal physiological processes resulting in loss of ability to respond to thyroid therapy apparently occurs with the increasing interval of time between thyroidectomy and therapy.

DISCUSSION

Investigations on the rôle of the thyroid in lactation, using small laboratory animals, are hampered by the lack of suitable techniques for measuring milk yield, for microanalysis of milk, and the difficulty of achieving satisfactory and complete operative removal. These factors may partially account for the conflicting results of thyroidectomy studies reported in the literature.

Although control operations were not performed, post-operative recovery among the experimental animals, as indicated by daily milk yield, was uneventful and effected in about four days.

In view of the recent report of Folley *et al.* (3) that the failure of lactation in rats after thyroidectomy can be considerably alleviated by administration of parathyroid extract, cognizance must be taken of the parathyroids in thyroidectomy studies. Information regarding the location, number, and function of the parathyroid glands of the bovine is limited. Fehland (1) reported finding one parathyroid body embedded on the lateral surface of each thyroid lobe, and accessory parathyroids scattered along the course of the thyroid arteries. Although the amount of functional parathyroid tissue removed from or retained by each cow in this study was not determined, the absence of post-operative or parturitional tetany, characteristic of thyroidectomized rats, minimizes the importance of parathyroid insufficiency as a causative factor of decreased lactation. Normal blood calcium levels observed throughout the experimental period further substantiates the conclusion that our cows retained sufficient parathyroid tissue to suffice for normal calcium metabolism. Restoration of lactation by the administration of parathyroid extract to thyroidectomized cows would lend further proof.

Inasmuch as the administration of thyroid or dinitrophenol to thyroid-intact cows causes increases in fat content of the milk without necessarily affecting the quantity of milk, the absence of selective response of either milk or fat yield to thyrotherapy in this study is worthy of comment. These results may be explicable on the assumption that the metabolic level was lowered to such an extent that both milk and milk fat secretion would benefit from exogenous administration, whereas in the thyroid-intact animal selective response may occur. In this connection it is significant to point out that the milk of the thyroidectomized cows was of normal specific gravity and contained normal amounts of lactose, total nitrogen and casein nitrogen.

Results of replacement therapy strongly suggest that lactational failure observed in the bovine after thyroidectomy is due to thyroid insufficiency. However, the definite physiological effects of thyroid insufficiency causing decreased lactation are unknown. Subnormal mammary development in animals thyroidectomized a considerable period of time before pregnancy, as observed in this study, may be a factor. This observation is, however, contrary to those of Leonard and Reece (8) who reported increased mammary development after thyroid removal.

Karnofsky (7) and others, noting the changes in the pituitary gland after thyroidectomy, have postulated a decreased output of the lactogenic hormone as a limiting factor of lactation. McQueen-Williams (9) found that thyroparathyroidectomized male rat pituitaries contained less lactogen than normal. However, Reineke *et al.* (13) report both the lactogenic and thyrotropic hormones present in the pituitaries of thyroidectomized male kids in normal concentrations. Restoration of lactation to normal in thyroidectomized animals by administration of prolactin would confirm this postulation.

Milk secretion is dependent upon an adequate supply of metabolites from the blood. A decreased supply of metabolites may be due to lower levels in the blood stream or to a decreased flow of blood through the mammary gland. A slight reduction of heart rate in the thyroidectomized cows was observed. Reineke and co-workers (13) have suggested a reciprocal relationship between the thyroid and pituitary whereby removal of the thyroid results in a decrease of the pituitary factors regulating the metabolism of sugar, fat, protein, and mineral matter. Only in their presence can large amounts of milk be made. Normal levels of blood sugar, total nitrogen, calcium, phosphorus, and fat were observed throughout the experimental period for the thyroidectomized cows in this study.

Considerable stress is placed upon general metabolism during lactation. Inasmuch as thyroidectomy causes a lowering of metabolic activity this is undoubtedly a contributing cause of the rapid decline of milk secretion after thyroidectomy. Whether or not thyroidectomy results in a distinct lowering of metabolic activity of the individual secretory cells of the mammary gland remains a moot question.

SUMMARY

1. Thyroidectomy performed on cows preceding gestation, during pregnancy, and during lactation caused a complete cessation of lactation in about 180 days.

2. Total milk and fat yield were reduced about 75 per cent.

3. Incomplete removal of thyroid gland produced a temporary decline in milk secretion followed by a gradual return to former levels.

4. Composition of the milk as determined by fat, lactose, nitrogen, and specific gravity analyses was not affected.

5. Milk and fat yields were restored to former levels by oral administration of fresh thyroid. Decreasing response was observed as the lactation period progressed.

6. It is concluded that the reduction of lactation after thyroidectomy is due mainly to thyroid deficiency.

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THE EFFECT OF COMPLETE EVACUATION OF THE MAMMARY GLAND BY PITOCIN UPON MILK AND FAT PRODUCTION*

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It is generally recognized that incomplete removal of the milk from the udder over a period of time will cause a decline in lactation. Partial removal of the milk has been used by many as a means of "drying off" cows. Miller and Petersen (4) observed marked downward trends in the lactation curve when cows were stimulated to "let down" their milk 20 minutes before milking began, resulting in incomplete evacuation of the gland.

While the reason for this effect of incomplete evacuation of the gland is speculative at the present it can best be explained by increased intra-alveolar pressures created by the retained milk. Petersen and Rigor (5) and Garrison and Turner (3) showed a decreased rate of milk secretion with increased pressures. The former observed complete stoppage of milk secretion when these pressures reached 30 mm. Hg while the latter noted that 40 mm. Hg pressure was needed to completely stop milk secretion. The increased milk production observed with increased frequency of milking can also be explained by the hypothesis that this practice prevents the development of as great pressures or the maintenance of high pressures over as long periods of time as does less frequent milking.

Since it has been established that incomplete evacuation of the udder over a period of time will cause a drop in the lactation curve, the question arose as to what part natural incomplete emptying of the gland plays in the decline of lactation with the advance in lactation. A second question is that of the effect upon the lactation curve of cows that are erratic in their let down of milk and if incomplete let down of milk might not be the cause of the rapid decline in the lactation observed in many cases.

As the oxytocic principle (2), when injected intravenously, has been shown to practically completely evacuate the alveoli, use of this hormone following milking enables one to ascertain the amount of milk remaining in the gland after a normal milking has been completed. Complete evacuation of the gland at each milking, by use of this hormone, will also make it possible to determine the effect of this procedure upon the lactation curve.

EXPERIMENTAL

To determine the effect of complete evacuation of the gland at each milking upon the lactation curve in the declining phase of lactation 5 cows in

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advanced stages of lactation were used. The cows were mature grade Holsteins designated as E 293, E 366, A 12, A 15, and A 30. They were all normal during the period of the experiment.

The experiment was divided into three periods of fourteen days each. For E 293 and A 15, injections were made in the second period and the first and third periods served as controls. E 366, A 12, and A 30 were injected during the first and third periods and the second period served as a control.

All cows were milked twice daily at twelve-hour intervals. E 366 was milked by hand and the others by machine. In the case of machine milking completeness of milking was checked by hand stripping. The milk obtained by hand or machine plus any stripping is referred to as normal milk.

During the injection period 1 cc. Pitocin containing 10 I.U. of the oxytocic principle was injected intrajugularly immediately after the completion of the normal milking. The milk obtained following the injection, referred to in this experiment as "pitocin" milk, was weighed and analyzed separately.

In addition to the weights of milk obtained at each milking, lactose (1) chloride (6) and fat determinations were made.

The effect of complete evacuation of the udder by injection of Pitocin was studied on three cases that deserve special mention.

Case 1. A grade first-calf Holstein heifer that apparently did not let down her milk.

Case 2. A purebred Jersey in a nearby herd in the third month of her second lactation period, with a short time lactation history that could not be explained on a basis of heredity.

Case 3. A purebred Jersey cow in the fourth lactation that was unusually erratic in the let down of her milk.

RESULTS AND DISCUSSION

A summary of the actual milk and fat production and fat percentage by periods for both the "normal" and "pitocin" milks is presented in table 1. It is customary in experiments with the setup used here to calculate the effect of the experimental procedure by comparison of the experimental with the control periods. This has been done in table 1 but caution should be registered in accepting those values as representing the absolute effect of complete evacuation of the gland by Pitocin because nothing is known about the effect of the injections upon subsequent periods and all cows were in the declining phase of lactation with no means of knowing what the normal slope of the lactation curve would be. With the exception of A 30 the evidence seems to be in favor of the Pitocin injections causing a greater increase in production than indicated by the calculations. Because of the injections the subsequent control period seems to be at a higher level than it would have been normally. It can therefore be said that in every case the complete evacuation of the udder by Pitócin injections causes a significant increase in the amount of milk produced.

The effect of the Pitocin injections upon the fat percentage is not so conclusive although the indications are that this value is also increased. In three of the cows there is the significant increase of fat percentage of 0.4 + while the decreases are 0.08, in both cases. It is to be noted that the "pitocin" milks are significantly higher in fat content than the "normal" milks. It is also noteworthy that the fat content of the "normal" milks during the injection periods are significantly lower than for the control periods.

TABLE 1

The effect of complete evacuation of the udder by Pitocin injections. Total milk and milk fat production and fat percentage by periods of 14 days each. For comparative purposes the milk production for a fourteen-day period previous to the start of the experiment was taken from the daily milk records. This is designated Control +

Cow number	Experimental periods	Milk produced during 14-day periods						Period of injection as compared to control	
		Normal milking		Pitocin milk		Total			
		Milk	Fat	Milk	Fat	Milk	Fat	Lbs.	% fat
		lbs.	%	*lbs.*	%	*lbs.*	%		
E 293	Control+	...	...	...	...	452.3	...	...	...
	Control	399.9	3.29	...	...	399.9	3.29	...	...
	Injection	320.2	2.98	99.7	6.31	419.9	3.77	+ 62.2	+ 0.42
	Control	315.5	3.41	...	...	315.5	3.41	...	...
A 15	Control+	...	...	...	...	435.7	...	...	...
	Control	386.9	3.49	...	...	386.9	3.49	...	...
	Injection	315.0	2.86	105.1	6.68	420.1	3.82	+ 45.8	+ 0.40
	Control	361.7	3.35	...	...	361.7	3.35	...	...
E 366	Control+	...	...	...	...	456.4	...	...	...
	Injection	363.6	2.84	102.0	7.16	465.6	3.79	...	...
	Control	410.2	3.34	...	...	410.2	3.34	+ 67.1	+ 0.43
	Injection	370.9	2.54	118.0	7.54	488.9	3.75	...	...
A 30	Control+	...	...	...	...	245.3	...	...	...
	Injection	229.0	3.58	24.1	7.68	253.1	3.97	...	...
	Control	234.5	4.06	...	...	234.5	4.06	+ 15.0	− 0.08
	Injection	217.1	3.56	28.7	7.20	245.8	3.99	...	...
A 12	Control+	...	...	...	...	149.3	...	...	...
	Injection	68.0	3.35	81.0	7.14	149.0	5.41	...	...
	Control	31.7	5.39	...	...	31.7	5.39	+ 59.8	− 0.08
	Injection	19.9	3.37	14.0	7.81	33.9	5.20	...	...

While the production of both milk and fat in the experimental periods exceed that of the control periods by significant amounts for E 293, A 15, E 366, and A 30; for A 12 the production during the experimental period only equaled that of the control periods. This can be explained by the fact that she was in the last stage of the lactation and the drop in daily production was precipitous when the experiment was started.

The lactose and chloride contents of the milk were unaffected by Pitocin injections.

To ascertain the effect of Pitocin injections with time the total daily milk and fat production for all periods were plotted. For the injection

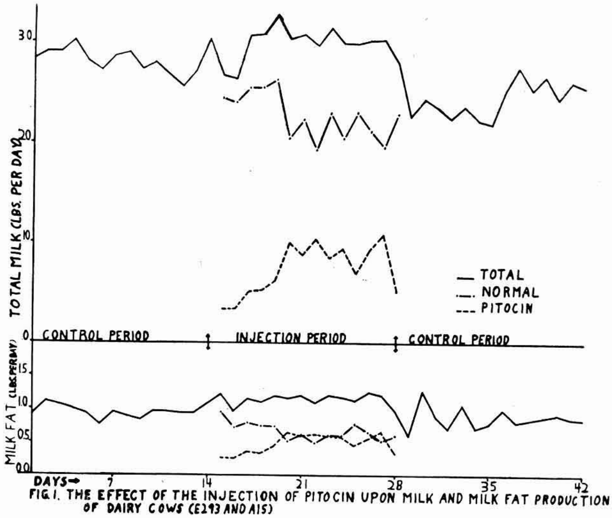

FIG. 1. The effect of complete evacuation of the udder by administration of Pitocin at each milking upon milk and milk fat production. The average daily milk and milk fat is plotted for E 293 and A 15.

periods the "normal" and "pitocin" milks and fats are also plotted. Because of the similarity of the curves these records of E 293 and A 15 are combined in figure 1 and for the same reason the records on E 366 and A 30

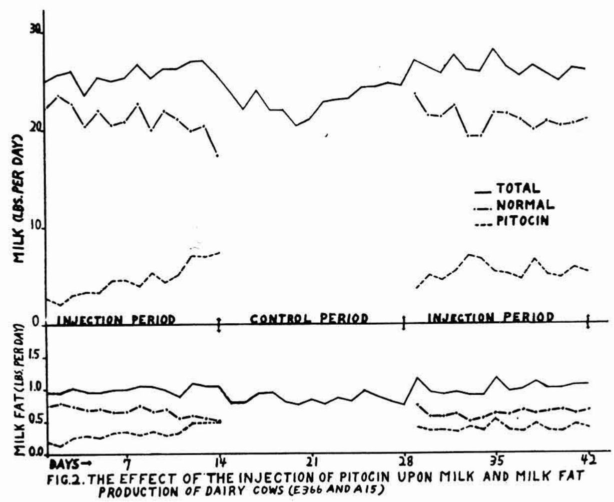

FIG. 2. The effect of complete evacuation of the udder by Pitocin administration upon the average daily milk and milk fat production on E 366 and A 30.

are combined in figure 2. The record of A 12 presenting a different picture is presented in figure 3.

As the injections continued during the 14-day periods, there was an upward trend in both total daily milk and fat production in spite of the fact that all of the cows were in decided declining phases of lactation. This trend is relatively the greatest in the second injection period in A 12 where also the drop was the most precipitous in the control period following the first injection period. This fact is taken as evidence that milk retained in the gland after normal milking is a contributory factor to the decline in production in late lactation. On the basis of the results on A 12 there is indication that "drying off" effect of the retained milk is the greatest in the most advanced lactation.

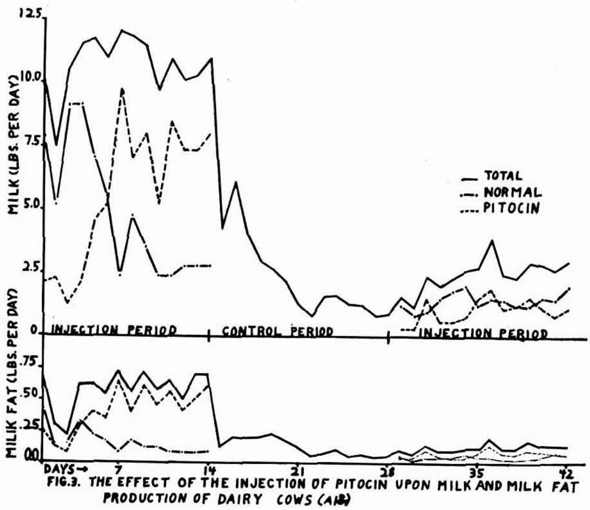

FIG. 3. The effect of complete evacuation of the udder by Pitocin administration upon the daily milk and milk fat production on A 12.

Another interesting observation is that as the injections continued there was a progressive decrease in the "normal" milk obtained and an increase in the "pitocin" milk and the shift in the ratio of the fat in the "pitocin" milk to that in the "normal" milk is even greater with the continuation of injections. This effect of Pitocin injections is the most prominent in the first injection period of A 12 (fig. 3) where in the whole period 68.0 pounds were obtained as normal milk and 81.0 pounds as "pitocin" milk while in the second half of the period the "pitocin" milk amounted to more than 3 times as much as the "normal" milk.

The reason for the observed phenomenon can only be speculative at this time. It is possible that the cows were becoming conditioned to the injections and did not respond as completely with the let down of milk to the normal milking. An alternate explanation is that the continued injections had a depressing effect upon the natural secretion of the oxytocic principle by the posterior pituitary body.

The results obtained by Pitocin injections into the 3 special cases investigated, adds confirmatory evidence to the depressing effect upon lactation of incomplete evacuation of the mammary gland even though such be from natural causes. Since each of the 3 cases present essentially different aspects of the problems they will be dealt with separately.

Case 1 can best be described as a first calf heifer that lacked the ability to respond with a ''let down'' of milk to the normal milking stimulus. The only milk obtained was that which had drained into the lower cavities of the udder and in the teats. She exhibited no nervous signs during attempts at milking and at no time could more than 3.1 pounds of milk be obtained at a milking in spite of the fact the size and appearance of the udder indicated a much greater producing capacity. After the small amount of milk was removed the lower part of the udder became ''soft'' but the upper two-thirds remained firm. After two weeks 1 cc. Pitocin was injected intrajugularly immediately after each milking and the additional milk removed. This procedure was continued for five days. During the injection period she averaged 16.2 pounds per milking of which 13.9 pounds were obtained following the injection of the hormone.

Upon cessations of the injections no more milk was obtained than during the first two weeks and at the end of two months milk secretion ceased. After evacuation of the gland following the injections it assumed the natural soft texture following the milking of an udder said to have good quality. The hardness of the gland was therefore due to the retained milk.

Case 2 differed from Case 1 in that she milked at normal levels after parturition but dropped off in production at a much more rapid rate than any of her closely related females in this herd. The case came to the attention of one of the authors when the owner explained the reason for the lack of persistency as being due to a ''meaty'' udder. She was then in the third month of lactation and was producing 9.5 to 10.3 pounds of milk per milking. After removal of this amount of milk the upper two-thirds of the udder remained hard or ''meaty'' as the owner had described.

Upon the intrajugular injection of 1 cc. Pitocin immediately after a normal milking of 10.1 pounds an additional 8.6 pounds of milk was obtained. Following the removal of this amount of milk the hardness or meaty condition of the udder had disappeared. Injections were continued by the owner for a period of 5 days with a reported increase of more than 50 per cent production. Upon cessation of injections she immediately returned to the former habit of incomplete evacuation of the gland.

As the amounts of milk obtained were far greater than the capacities of the cavities of the udder and teats and also as the amounts of milk obtained at milkings varied no more than could normally be expected it appears that in this case there was a uniform but incomplete response to the milking stimulus. Whether the lack of response was due to insufficient hormone secretion or to a decrease in the sensitivity of the gland musculature is conjectural.

Case 3 is a pure bred Jersey in the University herd now in her fourth lactation. Her history is of special interest and therefore her lactation curves for the first 3 completed and the 4th lactations to the present are given in figure 4. It will be noted that in her first lactation she was unusually persistent but in the subsequent ones the reverse is true.

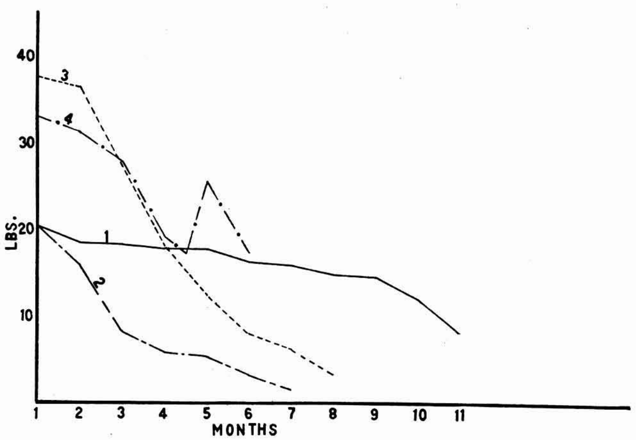

FIG. 4. The effect of erratic habit on let down of milk upon the character of the lactation curves, plotted by monthly averages except the portion of the fourth lactation where plotting is based upon weekly average. Successive lactations labeled 1, 2, 3, and 4. During the first lactation complete let down occurred at each milking.

Inspection of the daily milk records reveal that just before a marked decline appears in the lactation curves she becomes very irregular in the amount of milk obtained. It was not uncommon to obtain but two or three pounds of milk in a milking to be followed by one of fourteen to sixteen pounds. The variations in the month of her fourth lactation may be seen in figure 5. Following the milkings of small amounts the upper part of the udder remained hard while following the large milking it was soft and pliable. Inspection of the curve (fig. 5) for the first fourteen days reveals the probability that at some milkings there was apparently no response with a let down of milk while at others there was a partial response and sometimes a complete response. It is safe to say that the gland was completely evacuated in less than one-third of the milkings, which fact was responsible for the rapid decline in her lactation curve.

For fourteen days (14 to 28 in figure 5) 1 cc. Pitocin was injected intrajugularly immediately after each normal milking and the milk let down removed. The milk obtained following Pitocin injection as well as the total milk for each milking is plotted in figure 5. It will be noted that the variations in the total milk obtained per milking was reduced to minor fluctuations. There were, however, marked variations from milking to milking in the relative amounts obtained as "normal" and "pitocin" milk.

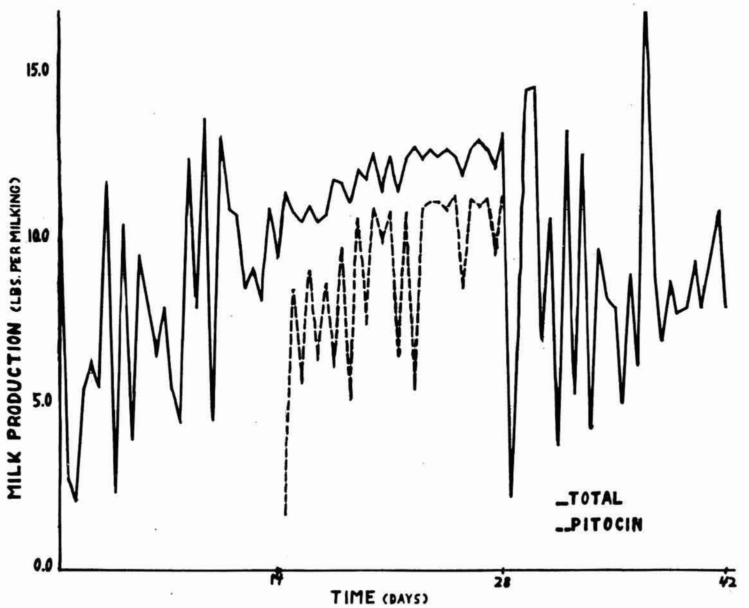

FIG. 5. The effect of complete evacuation of the udder by Pitocin injection upon the quantity of milk and uniformity of amounts of milk in a cow with erratic milking habits. Each milking is plotted. The first fourteen days is a control period. Pitocin was injected at each milking from the 15th to 28th day.

Using the milk production for the fourteen days immediately preceding the injection period there were increases of 44.8 per cent in milk and 59.31 per cent in fat for the injection period. It will be noted from figure 5, however, that the daily production increased for the first 8 days when a plateau is reached. Using the last six days of the injection period the production increased 56.9 per cent as compared with the average production for the fourteen days before injection.

As for the injections of Pitocin in cows in advanced lactation it is noted there is an increase in "pitocin" milk and a decrease in "normal" milk with continuation of the injections. It is noteworthy that the decreasing effect of the Pitocin injections upon the amounts of milk lasted for but one milking after injections were stopped. It is also noteworthy that in the 14-day period following cessation of injections the milk production is 5.1 per cent greater than in the 14-day period preceding injections instead of an estimated 15 per cent loss as would be expected from the trend of the lactation curve.

It would therefore appear that the complete evacuation of the gland at each milking by the use of Pitocin not only checked the downward trend of the lactation curve but in this case stimulated the gland into greater activity.

SUMMARY AND CONCLUSIONS

1. The results are given of complete evacuation of the udder by the injection of Pitocin upon the milk and fat production of five cows in the declining phase of lactation and of three other cases of natural incomplete let down of milk.

2. In all cases of declining lactation complete evacuation of the gland checked the downward trend of the lactation. In all but one case the milk production was significantly increased over the control period.

3. On the basis of the results obtained on three cows with the evacuation of the gland by the injection of Pitocin it is suggested that in many cases the lack of persistency is due to the incomplete let down of milk.

4. Any milk retained in the gland has a depressing influence upon subsequent production.

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CHANGES IN BACTERIAL COUNTS OF STORED ICE CREAM MIX

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In ice cream surveys conducted by this station excessively high bacterial plate counts sometimes were obtained on samples frozen from mixes which originated at plants whose products ordinarily were of low bacterial content. Although sanitation in the freezing plant undoubtedly was a factor in some instances, other causes were indicated in a sufficient number of cases to warrant study of the effect of time and temperature of storage upon the development of bacteria in ice cream mix.

Abele (1) reported only 80 per cent of the mix in the hands of the manufacturers and 75 per cent of that in possession of the freezers was held below 50° F. Temperatures of ice cream mix in transit commonly were found to rise above 50° F., and sometimes to 60° F., accentuating the problem of adequate refrigeration during storage in the plant where the mix was frozen.

METHODS

Samples of pasteurized mix were obtained from two sources and at different seasons of the year over a period of 15 months. During this period ingredients and formulae were changed, especially at one source, so the samples represented a diversity of composition. Each original lot of mix was agitated thoroughly and approximately 50-ml. quantities transferred aseptically to 2-oz. screw-cap sample jars. A number of replicate samples sufficient to provide an undisturbed sample from each temperature of storage at each plating interval was employed. The samples were held under commercial refrigeration conditions, periodic temperature readings being recorded. On some samples the temperatures may have exceeded the recorded limits for short unrecorded intervals, but the ranges given represent the temperatures in effect during most of the holding period. All platings were made by using the volumetric method, standard plate counts being on Tryptone-glucose-extract-milk agar incubated for 48 hours at 37° C., and coliform counts being on violet-red bile agar incubated approximately 20 hours at 37° C. The procedures used were those outlined in "Standard Methods for the Examination of Dairy Products" (2).

RESULTS

The results of the bacteriological examinations made after various intervals are recorded in table 1. The data indicate some lots of mix cannot be

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TABLE 1

Changes in bacterial counts of ice cream mix during refrigerated storage

Sample No.	Holding temperature range (°C.)	Standard plate count per ml. after holding for periods indicated			
		0 days	2 days	4 days	7 days
1	2.0–10.0	9,300	4,200	17,000	28,000
	13.0–14.5	9,300	10,000	1,500,000	75,000,000
2	4.5– 5.5	14,000	13,200	9,100*	11,700
	7.0– 8.0	14,000	19,000	9,800*	16,000
3	4.5– 5.5	41,000	92,000	178,000*	3,400,000
	7.0– 8.0	41,000	185,000	8,800,000*	68,000,000
	4.5– 5.5	2,500	4,500	2,300	23,000†
4	5.5– 8.5	2,500	6,300	280,000	19,000,000†
	12.8–14.5	2,500	9,700	1,500,000	47,000,000†
	3.0– 4.5	9,200	9,800	40,000	470,000
5	8.5– 9.5	9,200	35,000	920,000	30,000,000
	12.2–13.3	9,200	78,000	4,200,000	135,000,000
	3.0– 4.5	15,000	6,100	6,600	51,000
6	8.5– 9.5	15,000	7,100	150,000	9,500,000
	12.2–13.3	15,000	10,000	1,300,000	57,000,000
	3.0– 4.5	6,600	4,600	11,500	116,000
7	8.5– 9.5	6,600	8,700	180,000	5,400,000
	12.2–13.3	6,600	13,400	940,000	16,100,000
	1.0– 4.5	3,700	6,100	9,200	20,000,000
8	4.0– 5.0	3,700	4,500	24,000	53,000,000
	14.3–15.5	3,700	17,000	510,000	240,000,000
	3.0– 4.5	20,000	59,000	66,000	156,000
9	8.0– 9.5	20,000	115,000	7,000,000	61,000,000
	12.2–14.0	20,000	220,000	13,000,000	97,000,000
		Coliform count per ml.			
1	2.0–10.0	....	....	....	....
	13.0–14.5	....	....	....	....
2	4.5– 5.5	1	1	0*	7
	7.0– 8.0	1	2	13*	5
3	4.5– 5.5	320	380	380*	700
	7.0– 8.0	320	920	3,400*	18,100
	4.5– 5.5	1	1	< 1	1†
4	5.5– 8.5	1	1	72	4,900†
	12.8–14.5	1	6	> 100	710,000†
	3.0– 4.5	> 100	370	450	320
5	8.5– 9.5	> 100	450	410	160,000
	12.2–13.3	> 100	500	11,000	270,000
	3.0– 4.5	> 100	440	380	220
6	8.5– 9.5	> 100	590	630	500
	12.2–13.3	> 100	800	900	1,500
	3.0– 4.5	1	1	1	300‡
7	8.5– 9.5	1	4	7	420
	12.2–13.3	1	6	420	500
	1.0– 4.5	< 1	< 1	< 1	< 1
8	4.0– 5.0	< 1	< 1	< 1	< 1
	14.3–15.5	< 1	< 1	< 1	< 1
	3.0– 4.5	120	70	10	130
9	8.0– 9.5	120	350	16,000	320,000
	12.2–14.0	120	700	59,000	1,600,000

* = 5 days. † = 8 days. ‡ = Questionable coliform types.

held more than 4 days at temperatures slightly below 5.5° C. (42° F.) without significant increase in count. No relationship between initial coliform count and tendency for standard plate count to increase at this temperature is apparent. In some instances relatively high counts were obtained after holding the mix 7 days at 5.5° C. (42° F.) or below. Temperatures of storage ranging up to 9.5° C. (49° F.) commonly resulted in some increase in standard plate count after 2 days and a large increase in count after 4 days. Holding mix at this temperature for 7 days usually resulted in excessive counts. Holding at temperatures approaching 15.5° C. (60° F.) sometimes permitted considerable increase in standard plate count in 2 days and always resulted in excessively high counts after 4 days.

Development of coliform organisms was checked by holding temperatures of 5.5° C. (42° F.) or below. At temperatures approaching 9.5° C. (49° F.) the behavior of this group of organisms was erratic, considerable increases in count being encountered in some samples, while these organisms multiplied but little or not at all in this temperature range in other samples. Storage at temperatures of 12.0° C. (53.6° F.) and above resulted in marked increases in coliform count, even after 4 days.

In no case had the flavor or aroma of the mix been changed significantly during the holding period of 7 or 8 days.

DISCUSSION

The data indicate storage of mix initially having a low bacterial count may permit considerable increases in "total" count. These increases are of particular significance when temperatures above 5.5° C. (42° F.) are encountered. Increases in coliform count usually occurred when temperatures reached the level of 8.0° C. (46.4° F.) or above, but were not significant below this temperature level. Increases in numbers of these bacteria during storage could result in erroneous conclusions concerning magnitude of post-pasteurization contamination of the mix.

The data indicate the practice of making or purchasing mix and storing it under moderate refrigeration for several days before freezing may have an undesirable effect upon the bacteriological condition of the resulting ice cream. Hammer (3) showed more than 30 years ago that the bacterial content of frozen ice cream fails to increase, in fact usually decreases, during storage. Storage in the form of frozen ice cream, rather than in the form of unfrozen mix, is to be preferred in either the manufacturing or the freezing plant. If the temperature can be maintained below 40° F., storage of mix for not more than 2 days apparently would cause no bacteriological difficulties under usual conditions.

CONCLUSIONS

1. The bacterial count of ice cream mix stored at 4.5° C. (40° F.) or

above increases with storage time and may reach considerable magnitude as the storage temperature increases.

2. Coliform bacteria usually were found to increase in numbers in ice cream mix held at temperatures of 8.0° C. (46.4° F.) or above. This increase may give rise to false conclusions relative to post-pasteurization contamination based upon presence of coliform bacteria in appreciable numbers.

3. Storage of frozen ice cream, rather than unfrozen mix, is recommended.

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A SIMPLIFIED METHOD OF ESTIMATING 305-DAY LACTATION PRODUCTION*

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Records of 305-day milk and butterfat production are ordinarily estimated from monthly milk weights and butterfat tests. Probably the most widely used method is that recommended by the Division of Dairy Herd Improvement Investigations, Bureau of Dairy Industry. The D.H.I.A. method has become known as the centering method because the testing month is centered around an established testing day rather than coinciding with the calendar month. In addition to this, the method involves calculation of back-credit in cases of lactation beginning at certain times in the testing month. In an investigation using D.H.I.A. records many errors in calculation were found. The majority of these errors were made in calculating the back-credit period, but many others resulted from the considerable multiplication and addition involved. This means that unless much time is spent in checking records, selection of animals is likely to be based on inaccurate information. Any method which might be substituted for the present D.H.I.A. system should be simple enough to result in greater arithmetical accuracy and should yield a record which possesses those statistical properties important in genetic selection.

The summation of the first ten testing-day values multiplied by 30.5 suggests itself as a simple method which should result in less arithmetical error. In this study the statistical properties of records calculated by this simplified method have been compared with the same cows' 305-day production records computed by the D.H.I.A. centering method and with actual production records obtained by summing the daily milk weights for the first 305 days.

LITERATURE

Prior to the advent of the cow testing associations, producing ability in dairy cattle had been estimated from records based on weekly butter yield and daily milk weights. Other estimates were based on seven-day tests in the fourth month multiplied by the number of weeks in the lactation; and still others by adding the milk weights for three days per month over a 12-month period and multiplying this sum by 10 to estimate yearly production.

Since cow testing associations were established, records have been calculated in most cases by the D.H.I.A. centering method. In some cases, how-

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ever, a calendar month scheme which is based on monthly tests and the number of days the cow is milked during the month has been used, as well as another method which estimates the production for the period between two consecutive testing dates from the milk and butterfat yields of the later date. Still other estimates have been derived from daily milk weights and a monthly or bimonthly fat test, and Plum (8) has used the summation of the first eight testing-day yields in an investigation of the causes of differences in butterfat records.

Studies by Rabild (9), McCandlish and McVicar (5), McDowell (6), Copeland (1), Gifford (2), Kendrick (4) and McKellip and Seath (7) indicated that little difference exists between the averages of production records estimated by these various methods. Harris, Lush and Shultz (3) found no significant differences in repeatabilities of D.H.I.A., lactation and yearly production records.

MATERIALS AND METHODS

The milk and butterfat figures used in this study were obtained from the D.H.I.A. herd record books and the daily milk records of two Wisconsin State Department of Public Welfare herds. These figures represented the production between 1935 and 1941 of Holstein cows milked three times daily. In one herd (Herd I), the butterfat records on 257 lactations of 108 cows and the milk records on 160 lactations of 60 cows were used. In the other herd (Herd II), the study was based on the milk records from 81 lactations of 65 cows. The milk records calculated by the D.H.I.A. centering method and simplified method were compared with each other and with the actual production figures obtained by summing the first 305-days' milk weights. Only the former comparison, "centered" vs. "simplified," could be made with the butterfat records.

Differences in the means of the records were tested for significance using Student's "t" test for paired observations. Simple correlations between estimated and actual yields were calculated. The variances of the milk and butterfat records, calculated for each herd by both methods, were divided into portions due to cow differences and differences between records of the same cow. The repeatability of milk and butterfat estimates (correlation between records made by the same cow) was computed for each class of records, *i.e.*, for the simplified, centered and actual production figures.

RESULTS AND DISCUSSION

The analyses show that the simplified and centered estimates are highly correlated with each other for both milk and butterfat production, and that the actual milk records are also closely associated with the two estimates of milk production (tables 1 and 2).

The means of the centered records for butterfat and milk production are significantly higher than the averages of the simplified records in Herd I

TABLE 1

Correlations between milk records calculated by the simplified and centering methods and actual yield in Herds I and II

Herd	I		II	
Method	Simplified	Centering	Simplified	Centering
Actual	0.990	0.992	0.984	0.991
Simplified	....	0.995	....	0.984

(tables 2 and 3). These higher means are probably caused in large part by the back-credit additions used in the calculations of centered records. The tester tests all milking cows that are more than six days beyond calving at the time of his visit. Cows which both freshen and are tested during a testing period are given credit for the portion of the testing period they should lactate, less three days. Cows calving during an immediately previous testing period and not tested within that period are given credit (back-

TABLE 2

Statistics of butterfat records calculated by the simplified and centering methods in Herd I

Method	Number of records	Mean butterfat production	Standard deviation	Mean difference	Correlation between	
					Simplified and centered records	Intra-cow records
Simplified	257	507.8 ± 6.3	101.2	3.4*	0.993	0.24
Centering	257	511.2 ± 6.3	100.8			0.25

* $P < 0.01$.

TABLE 3

The actual, simplified and centered mean milk yields and differences between these means in Herds I and II

	Number of records	Actual	Simplified	Centering
Herd I	160			
Mean yield	....	14494 ± 207	14600 ± 210	14727 ± 212
Difference				
Actual	....	....	106*	233*
Simplified	....	....	....	127*
Herd II	81			
Mean yield	....	12683 ± 234	12769 ± 238	12565 ± 234
Difference				
Actual	....	....	86†	118*
Simplified	....	....	....	204*

* $P < 0.01$.
† $P \cong 0.03$.

credit) for the portion of the lactation which occurred in the previous period, less three days, on the basis of production during the present testing period. At each test (subsequent to the first) in the lactation of a cow, production is calculated for the testing period from the testing-day figures multiplied by the number of days in the testing period.

In a sense there are two groups of cows, one in which the cows start their records by receiving back-credit and another in which they do not. At the end of the record the ''back-credit'' cows will use only a part of the tenth testing period to complete a 305-day period. For the ''non-back-credit'' cows a portion of the eleventh testing period must be added to obtain an estimate of production over a 305-day period.

The simplified scheme also requires that each cow tested must have calved six or more days previous to the tester's visit, but no correction is made for day of calving (each testing-day value being multiplied by 30.5). Hence the simplified calculations give equal weight to the production on all of the first 10 testing periods, whereas the back-credit calculations give more weight to the higher production of the first testing period and less weight to the lower production of the tenth testing period than does the simplified scheme. Therefore, in ''back-credit'' lactations, the centered records are larger than those determined by the simplified method. On the other hand, cows receiving no back-credit will have lower centered records than simplified records because only a portion of the first testing period is used (the lower production of the eleventh period being used to complete the record), while in the simplified calculations equal weight is again given to all of the first ten monthly tests.

Furthermore, in the centering method the chances of cows receiving and not receiving back-credit are unequal. This grows out of the fact that a lactation record begins on the fourth day of lactation, whereas a test cannot be made until the seventh day of a lactation. Three days thus are added to the portion of the month in which a cow may calve and receive back-credit (average for different months of the year approximately 14½ out of 30½ days), and likewise the portion of the month in which they should not receive back-credit (about 16 out of 30½ days) is lessened by three days. The two periods therefore approximate 17½ and 13 days respectively. Thus the average of many centered records can be expected to be higher than the mean of corresponding simplified figures.

The simplified estimates of milk production in Herd II, on the other hand, are significantly higher than the centered records. The difference between Herd I and Herd II in these results seems to lie in the difference between these herds in regard to the deviations of actual testing dates from the established centering-day (table 4). In Herd I the deviations between the testing dates and centering-day are small, whereas the deviations in Herd II are large, varying from seven days before to 23 days after the centering-day.

Since the actual testing dates in Herd II were usually later than the fixed centering-date (ave. = + 7.8 days), the testing days were near the end of the testing period. This means that cows which would have received back-credit (*i.e.*, freshened after the seventh day before the tester's visit) if the actual testing date had been closer to the centering-day would be included in the first testing period of that lactation, and therefore receive no back-credit. The increase of non-back-credit lactations in this herd undoubtedly explains why the centered records are lower than the simplified records in Herd II (table 3).

The means of the simplified estimates are significantly larger than the means of the actual milk yields in Herds I and II (table 3). One explanation for this is that the first test is frequently made at a time when the cow is producing at a higher rate than the average for that part of the first 30.5-day period in which she is actually in production. In addition, cows tested soon after freshening are given credit for production, in the period before they begin production, at a higher level than that which is used (after the tenth testing period) to complete the 305 days of actual yield.

TABLE 4

Deviations of actual testing dates from the established centering-day in Herds I and II

Herd	No. of testing periods	Average deviation (days)	
		Arithmetic	Algebraic
I	72	1.9	− 1.7
II	42	9.7	+ 7.8

The significantly higher mean of the centered records compared to the mean of the actual milk yields in Herd I (table 3) is caused, in part at least, by the centering scheme's back-credit calculations. Part of this difference between means arises from the large number of records of ''back-credit'' cows, in which the rate of production used to calculate back-credit is higher than the actual rate of production during this back-credit period. It also arises from the ''non-back-credit'' records in those cases in which the tester's first visit comes near to the peak of the lactation curve.

The data for Herd II show that the average of the centered estimates is lower than the mean actual milk yields. The consistently late testing dates in this herd are undoubtedly the explanation for this lower mean. That is, the frequency of the ''back-credit'' cows is reduced about half, and the production estimates for the centering periods during the declining phase of the lactation curve are based on testing day yields taken near the end of each period; at this time the yields are lower than the average actual daily yields for those periods.

The repeatabilities (intra-cow correlations) for the two estimates of butterfat and milk production and for actual milk production are given in tables 2 and 5. There is not a significant difference between the repeatabilities of the simplified and centered estimates of butterfat production, nor are there any significant differences between these repeatabilities for the simplified, centered and actual milk records within herds.

TABLE 5

Repeatabilities of simplified and centering methods and actual milk production records in Herds I and II

Herd	Number of cows	Simplified	Centering	Actual
I	60	0.36	0.35	0.38
II	16	0.55	0.53	0.52

SUMMARY AND CONCLUSIONS

A simplified scheme for computing 305-day milk and butterfat records has been described, and such records have been compared statistically with those estimates calculated by the D.H.I.A. centering method and with actual 305-day milk figures.

The high correlations found between simplified, centered and actual milk records and between simplified and centered butterfat estimates, and the close similarity of their intra-herd repeatability figures and mean yields for milk and butterfat production indicate no important differences between the simplified and centered schemes.

The simplified scheme would offer, however, the following advantages:

1. It would avoid most of the sources of those arithmetical errors which so often occur in the centered calculations.
2. It would facilitate the training of testing supervisors.
3. It would provide the tester with extra time so that more cows could be tested in one day, or more time could be devoted to conferences with the dairy farmer.
4. It would allow the dairy farmer to understand readily the method used in estimating production records, and to make the calculations himself if necessary.
5. It would save much time in the recording and checking of production data which are to be used for research purposes.

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THE STRUCTURE AND PROPERTIES OF THE NATURAL FAT GLOBULE "MEMBRANE"*

A Historical Review with Experiments Bearing on a Physico-Chemical Explanation

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HISTORICAL

Babcock (2) probably was the first American chemist to investigate emulsion character of milk and cream and to reject Ascherson's (1) haptogen membrane theory which had already prevailed for 45 years.

According to Babcock (2), in 1885 the fat globules were considered to be either (a) "particles of free fat, in the form of an emulsion with the serum of the milk," or (b) "surrounded by a thin membrane, and therefore cells filled with fat," or it was believed (c) "that the albuminous matter of the milk is attracted and in some way condensed upon their surface, forming what is called *haptogenic* membrane."

It is not clear why Babcock distinguished between the "cells filled with fat" and the haptogen membrane theory of Ascherson (1) (whom Babcock did not mention by name) since Ascherson's paper clearly considers capillary condensation of albumin and aggregation of an infinite number of small particles at fat surfaces to produce "haptogen" membrane as identical descriptions of the property of "hymenogeny" which he discovered. Furthermore, Ascherson not only postulated that the fat globules in milk are surrounded by a "haptogen" membrane but he claimed to have seen the membrane by microscopic observation, both in natural milk and in artificial emulsions of olive oil in dilute egg albumin solution.

Babcock disagreed with those who claimed to have seen the membrane both intact and after rupture as the "broken sacks" of the fat globules by suggesting a possible "lack of skill in the use of the microscope" as well as "influence of a preconceived opinion." It is obvious that Babcock himself favored the emulsion theory to account for the fat globules. An emulsion, he stated, is produced by dispersing liquid fat in an aqueous fluid having viscous properties whereby the fat particles are prevented from uniting again "by a thin film of liquid analogous to that which separates the bubbles of air in foam or soap suds." Babcock then pointed out the analogies between milk and artificial emulsions, (a) in microscopic appearance,

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(b) in creaming and the accentuation of the same by dilution with water, (c) on churning, especially the relation thereto and importance of temperature and melting point of fat, and (d) on their behavior when treated with ether. As a convincing argument Babcock pointed out that churns which had formerly been designed with the view of rupturing the haptogenic and other alleged membranes surrounding the fat globules were being replaced with those which would accentuate aggregation and coalescence of the fat globules into granules and of the granules into butter.

Babcock was soon led to modify his views somewhat regarding fat globule "membranes" due to his conclusion that traces (Babcock estimated 0.0002 per cent) of fibrin normally form in milk. In 1889 (3, 4) Babcock presented the evidence for the formation of "lacto-fibrin" and discussed the importance of this phenomenon at considerable length. While neither the evidence nor the alleged practical applications of the phenomenon are any longer valid, it is of interest that Babcock sought by means of his conclusions to explain the natural agglutination of the fat globules,[1] the relation thereto of gravity and centrifugal creaming and its influence on churning. Babcock believed that in cream the fibrin "clots have practically the same effect as would a true membrane covering the globules, and must be removed before the globules can unite in the form of butter." The acid of ripened cream was regarded as an effective solvent for this purpose. At the present time students who are being introduced to current theories in dairy chemistry are usually surprised to learn that while Babcock was one of the first to call attention to the natural fat globule clustering phenomenon, and later (5) showed its importance in explaining changes in the "consistency" (viscosity) of milk, he nevertheless regarded fat clustering as detrimental to the creaming and described methods for preventing it.

Current theories about the emulsions which occur naturally in biological material permit the acceptance of aggregates of oriented colloidal particles at the surface of milk fat globules to form "membranes" such as were not visualized by Babcock. Some of Ascherson's views, however, were remarkably prophetic of later discoveries.

The fact that milk plasma contains a number of proteins each capable of effective stabilization of fat emulsions has been the cause of much of the confusion in the literature as to whether cows' milk possesses a special fat emulsifying system. For a number of years I have employed the term membrane in quotation marks to describe this system. A major part of this literature, both old and more recent, may be found in the following publications (6, 16, 17b, 18, 20, 25, 30, 31).

Although Babcock (2) recognized that the milk emulsion is not destabilized by dilution with water, the Danish chemist Storch (24) was the first to

[1] The occurrence of a true agglutinin in milk which is adsorbed by the fat globules at low temperatures, causing their agglutination, is supported by the paper of Sharp and Krukovsky (JOUR. DAIRY SCI., 22: 743–752, 1939) in which the older literature is reviewed.

apply this fact to the problem of isolating the natural emulsifying agents through the process now commonly called cream washing. Separator cream is diluted with distilled water at approximately body temperature (Storch used both water and sucrose solution) to give a fat content similar to whole milk and the diluted cream reseparated. If one starts with fresh cream from the freshest possible milk this process may be repeated until the tests of the washings for milk plasma constituents are essentially negative without impairing the stability of the emulsion. Surface and interfacial adsorption equilibria are, of course, sensitive to temperature changes. If the cream washing operation is conducted at animal temperature it is reasonable to conclude that the fat globules of such washed cream are "coated" by the emulsifying agents present when the milk is secreted together with other substances whose presence could be explained by chemical or physical affinity with the fat or its emulsifying agents. With these hypotheses as a background, it becomes largely a chemical problem to isolate and identify the natural "membrane" components.

Storch's (24) experiments pointed the way to an important aid in the isolation of the "membrane," which I and my associates (16) developed and employed extensively in our later studies (17a, 18, 20, 25, 30, 31), namely, the release of a large part of the protective agents into the buttermilk during the churning of washed cream whereby both the free buttermilk and that released by melting the butter become important source materials for chemical studies. Indeed, not only was it found (20, 29) that the emulsion properties and churnability of artificial emulsions of milk fat in the various colloidal sols from milk plasma are strikingly different from those of washed natural cream but also that the "membrane" materials isolated from the washed artificial creams are also chemically distinct from the natural "membrane" substances.

Only a relatively brief account can be given of the discovery of the specific components of the natural "membrane." Storch (11) first postulated a specific protein but its supposed mucoid nature was not substantiated. The protein is salted out of aqueous sols like a globulin (16) but does not require electrolytes for dispersion (18). As isolated by Hattori (10), by Samuelsson (16) and by Wiese (18), by Rimpila (20), and by Tarassuk (17b), and by Schwarz and Fischer (22), the protein is characterized by a N content several per cent lower than that of any other milk protein, a fact not yet explained either on the basis of known amino acid composition or identified prosthetic groups (30, 10, 22). The biological specificity of the protein was established by Lewis (15).

Dornic and Daire (8) postulated that the higher lecithin content of buttermilk than of whole milk arose from the release of lecithin from Storch's fat globule "membrane" but Samuelsson (16) first supplied direct evidence in support of this hypothesis by isolating phospholipides from washed cream buttermilk. Wiese (18) later identified lecithin, cephalin and sphingomyelin-like phosphatides in the natural "membrane" material. Thus, the specific emulsion stabilizing agent of cow's milk was finally established as a protein-phospholipide complex. Its aqueous sol was found (18) to have an isoelectric point at pH 3.9–4.0. The importance of the phospholipides in the hydrophilic properties of the membrane has been emphasized by Pyenson and Dahle (19). Sandelin (21) believes that lecithin is the more important component of the membrane in explaining the stability of the milk and cream emulsion.

A third major lipide component of the isolated natural "membrane" was encountered by Wiese (18) and Rimpila (20) in the form of a neutral, high melting glyceride, the significance of which is still obscure.

The more important components of the natural "membrane" present in minor quantity are enzymes and heavy metals. Toyama (26) first showed that the crude "membrane" serves as a satisfactory concentrate of xanthine oxidase, thus confirming the view of Wieland and Macrae (29) that cows' milk dehydrogenase is closely associated with the fat globules. Sharp (23) states that about one-half of the xanthine oxidase may be removed from the fat globules by washing. He also reports that milk contains about 70 milligrams of the enzyme per 100 grams of fat. This would constitute 12–15 per cent of the protein of the membrane, based on Rimpila's (20) data regarding the protein : fat relationship of washed cream. Xanthine oxidase being a riboflavin-protein compound accounts for the fact that both raw sweet cream buttermilk and the buttermilk from churning washed cream have a brownish-yellow color. Kay and Graham (13) first demonstrated that phosphatase is concentrated on the fat surfaces of milk. Rimpila (20) found that 50 per cent of the Kay-Graham phosphatase of fresh cream remains after six washings, each with four volumes of water. Davies (7) found that the "membrane" protein readily combines with copper and iron which dissolves in milk and cream in milk processing plants, thus causing a concentration of these metals on the surface of the fat globules. The probable importance of metallic ions, especially of copper ions that might arise from these compounds, in contributing to the oxidative deterioration of cream and butter, may readily be conjectured.

EXPERIMENTAL

The character of the specific components of the natural fat globule "membrane" of cows' milk so far identified raises both physiological and physico-chemical questions regarding their origin. The supposition that they are artifacts of the cream washing procedure is not rational. Physiological explanations of their origin are still in the realm of speculation but it is difficult to ignore the thought that there is some intimate relationship between them and the synthesis and secretion of milk fat. The physico-chemical aspects of the question are capable of experimental approach. Milk plasma contains colloidal systems which are excellent emulsion stabilizers. If it could be determined that the specific components of the natural membrane are preferentially adsorbed by a milk fat surface because of normal differences in their interfacial tension reducing ability as compared with the plasma colloidal systems, the origin of the natural "membrane" would have a physico-chemical explanation which could be regarded as at least plausible.

Dr. M. E. Powell carried out an extensive study of this question in my laboratory during 1932–34.[2] None of the results have heretofore been pub-

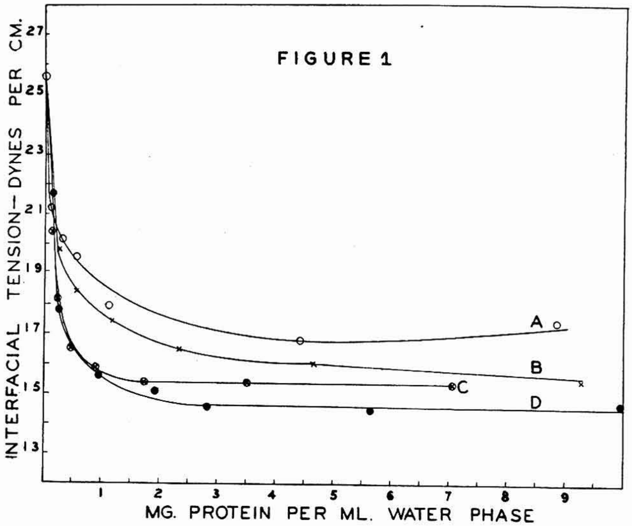

FIG. 1. Comparative tension reducing ability at water-butter oil interface of proteins (1) in lactalbumin sol A; (2) mixed milk serum protein sol B; (3) milk plasma sol C; and (4) calcium phosphocaseinate sol D, pH 6.7. Readings at 40° C.

lished. Using the drop weight method of Harkins and Brown (9) the interfacial tension reducing ability of different concentrations of the various colloidal systems of milk, including the natural "membrane" system, was determined at a butterfat-water interface at 40° C. This made it possible to determine at what concentration of protein a minimum interfacial tension was attainable for each system and gave a comparison both of the absolute ability of each material to reduce the interfacial tension of the butterfat-water interface and of the relative effectiveness of each to produce its own minimum tension.

In this work we observed for the first time that freshly washed fresh cream is sufficiently stable to withstand homogenization at 3000 lbs. pres-

[2] This work was supported by a grant from the Rockefeller Foundation.

sure at 105° C. This suggests that the materials remaining at the fat surfaces of washed cream represent either multimolecular layers or monomolecular complexes capable of considerable distensibility without impairment of the stability of the emulsion. The capacity of the resulting interface to adsorb the various colloidal capillary active systems of milk was examined experimentally in interfacial tension studies.

Figures 1, 2, 3, 4 and 5 present graphically some of the results of the various interfacial tension measurements.

Figure 1 shows the relative interfacial tension reducing ability of (a) lactalbumin sol (whey dialyzed against distilled water), (b) milk serum proteins sol (whey dialyzed with addition of NaCl), (c) milk plasma (skim

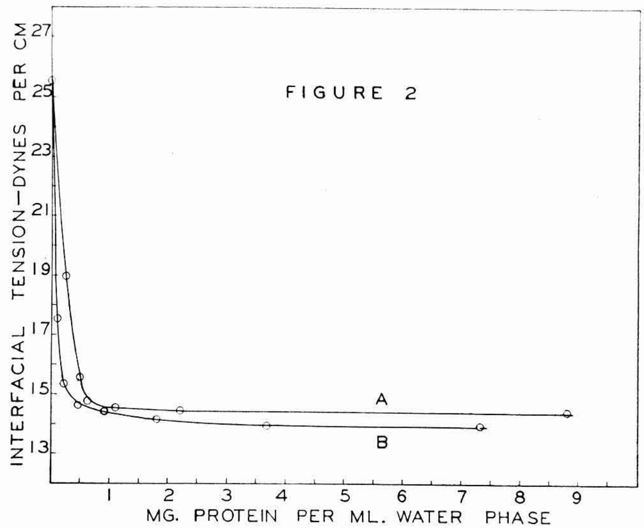

FIG. 2. Comparative tension reducing ability at water-butter oil interface of proteins in (1) milk plasma sol A; (2) sweet cream buttermilk B, from the same milk. Readings at 40° C.

milk) and (d) calcium phosphocaseinate sol (pH 6.7), each per unit of protein, their effectiveness being in the order named. Figure 2 shows the definitely greater effectiveness of sweet cream buttermilk over milk plasma proteins in reducing interfacial tension, both products being from the same original milk.

Figure 3 shows the markedly greater effectiveness, on the protein basis, of buttermilks from the melted butters of washed creams (curves A and B) than of the free buttermilks of the same washed creams (curves C and D) in reducing interfacial tension. These results seem to support the recent findings of Maĭmistova (14) that the capillary activity of the fat globule "membrane" is conditioned by its phospholipide compounds. We have, in our laboratory, unpublished evidence that relatively greater proportions of phospholipide remain in the butter churned from washed cream than is liberated in the free buttermilk. The findings of Sandelin (21) also support this.

Figure 4 shows the effects on interfacial tension between butterfat and homogenized washed cream of additions to the latter of two samples of milk plasma (skim milk), curves A and B, a calcium phosphocaseinate sol, curve C, and a concentrate of free buttermilk from an unhomogenized portion of the same washed cream which had been homogenized, curve D. The rise

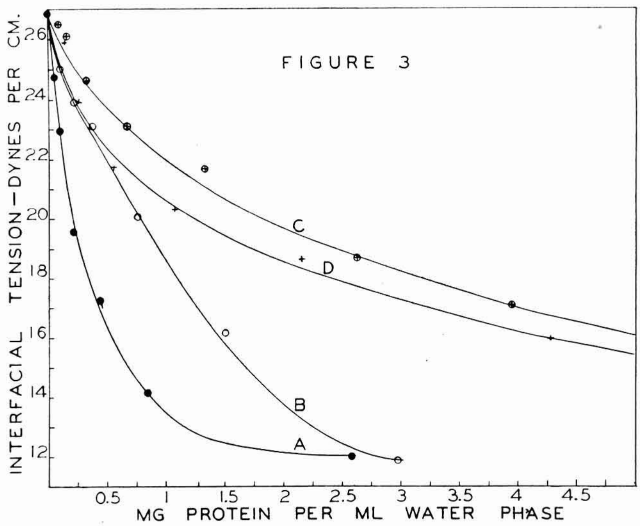

FIG. 3. Comparative tension reducing ability at water-butter oil interface of protein in (1) buttermilks from melted butter of washed creams A and B; (2) free buttermilks C and D, sols A and C being from the same washed cream, likewise B and D. Readings at 40° C.

in interfacial tension after the minimum had been reached in curves C and D suggests regions of concentration of the materials where less adsorption of capillary active colloids on the homogenized fat globule surfaces occurred. Why this should be so is not clear. Attention is called to the fact that figure 4 requires a different interpretation than figures 1, 2 and 3 since we are probably dealing here with colloids which remain free to reduce the tension between the butter oil and the water phase of the homogenized washed cream after the fat surfaces of the latter have attracted such material as can be adsorbed.

Figure 5 shows further evidence in support of the conclusions drawn from figure 3, that the phospholipide-protein complex retained by the butter of washed cream is more effective, on the protein basis, than the free butter-

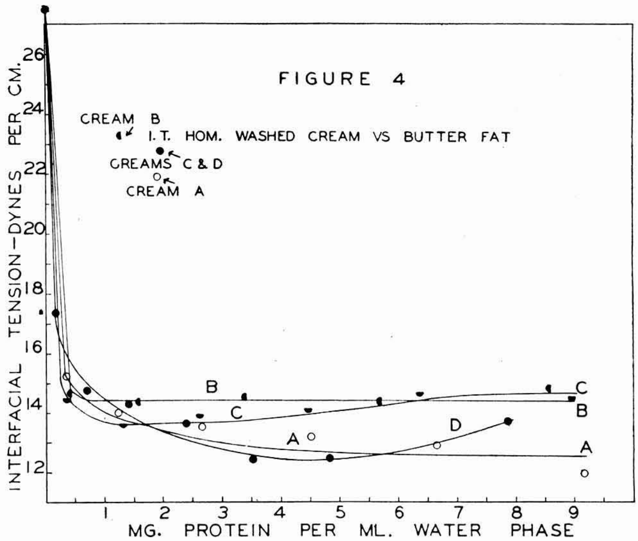

FIG. 4. Comparative tension reducing ability at homogenized washed cream-butter oil interface of proteins in (1) milk plasmas A and B; (2) a calcium phosphocaseinate sol C; and (3) a concentrate of free buttermilk D from an unhomogenized portion of the same washed cream which had been homogenized to furnish the interface. Readings at 40° C.

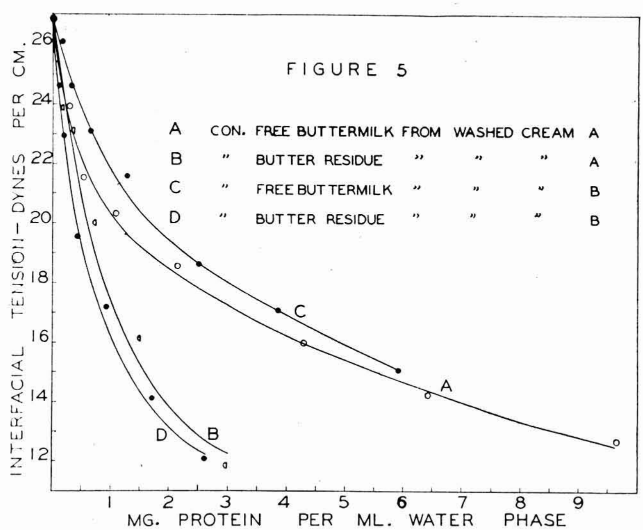

FIG. 5. Comparative tension reducing ability at water-butter oil interface of proteins in (1) concentrated free buttermilk A and concentrated aqueous phase of butter B, both from the same washed cream *A*; (2) concentrated free buttermilk C and concentrated aqueous phase of butter D, both from same washed cream *B*. Readings at 40° C.

milk from the same washed cream in reducing the tension at a melted butterfat-water interface.

General importance of "membrane" in dairy technology. The demonstrated fact that the fat phase of cows' milk is stabilized by a complex (or complexes) of the lecitho-protein type, involving a specific protein and having associated with it concentrations of redox and phosphatase enzymes, suggests numerous problems involving their probable importance in dairy technology. Both Wiese (18) and Rimpila (20) found certain variations in composition of the natural "membrane" which are no doubt of considerable significance. The relation of these facts to various theories of churning has been discussed by Palmer and Wiese (18). It cannot be questioned that there is considerable release of natural "membrane" during the churning and theories supposing the necessity of foaming and of coagulation of the "membrane" protein are made untenable.

Thurston and Barnhart (27) found important relations to exist between "richness" of flavor in milk products and the phospholipide fractions of the "membrane." Thurston and associates (28) presented evidence supporting their belief that certain off flavors of milk, particularly oxidized flavor, are associated primarily with chemical deterioration of the lecithin of the fat globule "membrane" rather than with oxidation of the butterfat itself. Jack and Dahle (11) have presented evidence suggesting the probability of a double layer membrane on the surface of the fat globules, the outer layer of which must be removed in order to secure centrifuged cream of highest fat content. That the natural "membrane" material released during churning may explain, in part at least, the low curd tension of sweet cream buttermilk is indicated by experiments carried out in the author's laboratory (17a). Many of the normal properties of natural cream have been found to require the natural "membrane." This is true for centrifugal cream separation, gravity creaming and churning (30) and for desirable whipping properties of ice cream mixes (12). For the latter the significant aspect is the protein-phospholipide complex which is thus capable of being imitated by other natural complexes of this type, *e.g.*, by that in egg yolk.

SUMMARY

The fat globules in cows' milk are wholly or partially surrounded by a special group of substances whose origin may be due, in part, to their greater capillary activity. The other surface active substances occurring in major concentration in milk plasma evidently constitute the outer layers of the fat globule surfaces if indeed they are normally concentrated there at all. The latter are readily removed when cream is washed by dilution with water. Experimental work in the author's laboratory and by numerous other workers cited, has pointed to the importance of the natural "membrane" of the fat globules in creaming, churning, milk flavor (both normal and oxidized),

decreased curd tension of natural sweet cream buttermilk, and in determining the desirable whipping qualities of ice cream mixes.

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IMPROVING THE QUALITY OF SWISS CHEESE BY CLARIFICATION OF THE MILK[1]

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It is commonly recognized that good quality in the milk is an important factor in the production of high quality cheese. For making Swiss cheese the suitability of any milk appears to be enhanced by the agitation or centrifugal treatment given milk by clarification. Orla-Jensen (20) was the first to observe that centrifuging milk resulted in improvement in Emmentaler (Swiss) cheese by the formation of fewer and larger eyes, and that a similar effect resulted when the cheese milk was filtered and likewise when it was agitated more than usual while being transported for a long distance. This process for improving Swiss cheese was first described in this country by Matheson in a preliminary report (16) and in a public service patent (17) from these laboratories. Its use has resulted in such marked improvement in eye formation and in the quality of the cheese generally that it has been adopted in practically all Swiss cheese factories in this country. The most obvious effect on the quality of the cheese is an increase in the size of the eyes and a decrease in their number, this resulting in a distinct improvement in grade and market value. The effects on the cheese appear to be caused by alterations in the composition of the milk and in the physical condition of the constituents of the milk, both of which factors result in conditions conducive to bacterial action of a type which favors the development of the proper texture in the curd and desirable eye formation.

Previous to 1924 little was known as to the mode of action of clarification in improving the quality of the cheese. It was thought to come about through "removal of dirt or other cellular elements from the milk" (17), and it was mentioned also (16) that the process "breaks up the clusters of fat globules." Orla-Jensen (20) believed that the improvement resulted from the effects of agitation in distributing uniformly gas-forming organisms, especially those associated with particles of foreign material. More recently, Guittonneau and his associates (6) indicated that particles of for-

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[1] The cheesemaking phases of the investigations were directed by the late Kenneth J. Matheson, who was largely responsible for improvement in quality of domestic Swiss cheese by clarification. The introduction in the factories of the clarifying process, and also of the pure culture method, was accomplished largely by other former employees, including Sumner A. Hall, Robert E. Hardell, James A. Boyer, Robert R. Farrar, and Fred Feutz, and by H. R. Lochry of this Division.

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eign material, when deposited in the cheese, act as centers of proliferation of undesirable gas-forming organisms, and that the improvement in eye formation results from the removal of large numbers of the organisms that occur as contaminants in and on the heavier particles of sediment.

Some of the favorable effects reported as due to clarification of milk on cheese include increased firmness of body of Swiss cheese (16), improved body (3, 5, 34) and flavor (3, 5, 22, 34) of Cheddar cheese and the prevention of gassiness, pinholes, and sponginess (1) in the curd of Cheddar cheese.

Reports of the effect of clarification on the milk in the removal of extraneous matter and cellular material have shown that the clarifier removes practically all visible sediment (10, 13, 19), that a portion of the fibrin (common in mastitis milk) is removed (13), that from about two-fifths to about two-thirds of the leucocytes and body cells are removed (4, 7, 10) and many of those remaining in the milk are fragmented (15), and that the proportion of cells removed increases as the temperature of clarification is increased (10). Some investigations have shown that the larger types of organisms are removed in greater proportion than the smaller ones (13), and also that, when the rate of flow of milk through the bowl is reduced, there is some selective removal of different types of bacteria, causing actual decreases in plate counts (34). On the other hand, the numbers of streptococci in the milk are not reduced significantly (28) and investigators (4, 7, 10, 13, 34) have agreed that clarification results in an increase in the total number of bacteria in the milk as determined by the plate count, due to breaking up of chains and clumps of bacteria. This change in the bacterial flora by clarification does not improve the keeping quality of the milk, since it has been shown that the methylene blue reduction time is often decreased (10, 28) and that there is a slight increase in the rate at which acidity develops (7, 19, 28).

It has been stated that clarification results in a reduction in size and an increase in the number of fat globules (19, 4) in milk and breaks up fat clumps (4). It is well known that, at temperatures used commonly, the process causes a decrease in the rate of creaming and a decrease in the volume of gravity cream (4, 7, 10, 14, 19, 33); at relatively high temperatures it causes an additional decrease in the volume of gravity cream (4, 10, 33). A reduction in the volume of gravity cream is produced also by pumping milk with a centrifugal pump (33), and by mechanical agitation (30). The latter treatment was found to break up clusters of fat globules. Agitation is believed to alter the surface characteristics and adsorption on the fat globules (11), with which the creaming property is associated (21); the fat-clustering agent, agglutinin, believed to be present in milk, is thought to be removed to some extent by agitation and centrifugal force (8); and the agglutinating material, when adsorbed on the surfaces of solid fat globules, can be released rather readily (27) by such a mild treatment as raising the temperature to above that of the melting point of the fat. Further indication that clarification of milk alters the nature of the fat is provided by evidence that, in the manufacture of dried milk, clarification of the milk increases the resistance of the fat to oxidative decomposition and improves the keeping quality (9).

The alteration in the gaseous content of milk resulting from the centrifugal agitation in the clarifying process may be considered as another desirable factor attributable to clarification in the manufacture of cheese. Babcock (1) showed that the centrifuging of milk tended to prevent gassiness in Cheddar cheese curd and he believed this effect was due to aeration, which presumably alters conditions for bacterial growth and inactivates certain types of gas-forming bacteria. Marshall (12) found that agitation of milk promoted an interchange of gases, thus increasing the ratio of oxygen to carbon dioxide, and that such an interchange inhibited undesirable fermentations. Results of Matheson (16) showed that the addition of ozone or of oxygen to milk inhibited the gassy fermentation produced by a vigorous, gas-producing, spore-forming anaerobe in Swiss cheese, without apparent injurious effect on eye formation or on development of the lactobacilli in the cheese.

It is obvious that clarification effects removal of the extraneous matter and also alters the physical properties of some of the constituents of milk. The evidence available indicates also that the changes produced by clarification result in conditions more favorable for the growth of the types of organisms that are useful in the cheesemaking process. From the wide variations that appear in the quality of cheese made commercially from clarified milk, however, it appears that its effects are more pronounced in milks possessing certain abnormalities, and that in some cases the milk is not clarified properly. This paper is a report of experiments designed to contribute additional information on the effects of clarification on the properties of milk; to study the effects of certain related treatments of milk which influence the quality of Swiss cheese; and to verify in a quantitative way the effects of clarification on the quality of the cheese. During part of this investigation there was available a supply of milk selected from cows having mastitis, and the results of clarification studies on this milk are included because of the unusually pronounced improvement that occurred when abnormal milk of this type was clarified.

METHODS

In efforts to account for variations in the quality of the cheese, those properties of milk which appeared to be of possible significance were determined in samples of the mixed milk taken from the cheese kettles. Counts of clusters of fat globules and of numbers of globules per cluster were made, at a temperature of 25° to 26° C., by means of a microscope in milk samples diluted 1:24 in an aqueous solution containing 1.5 parts of gelatin and 1 part of phenol per 100 parts. The phenol was used as a preservative in the gelatin solution after it was determined that its presence in the test did not affect the tendency of the fat globules to form clusters. Pairs of samples were placed in a calibrated Levy counting chamber (hemacytometer) with double ruling and allowed to remain for one to one and one-fourth hours for clustering to occur before counts were made. At least 50 fields per sample were examined. Groups containing 10 or more globules together were counted as clusters. For measuring sizes of fat globules an ordinary cover glass was used on the counting chamber and measurements were begun at once without allowing time for clustering to occur. A calibrated ocular micrometer disc, and also an ocular disc with circle and cross lines, were used in measuring and counting.

The creaming ability of milk was measured in samples held for 24 hours in 100-ml. graduated cylinders of uniform height immersed in a water bath at 3° to 5° C. (graduated cylinder method).

The creaming ability of milk was measured also by a centrifugal procedure designed to shorten the time required for the completion of creaming and designated as the cream test bottle method. Large-bodied, 50 per cent, nine-gram cream test bottles were selected which, when filled to the 50 per cent mark, contained not less than 55.2 ml. Two 17.6-ml. samples of milk, a total of 35.2 ml., were pipetted into each bottle and 20 ml. of water was added. The sample was mixed thoroughly and then centrifuged for one hour at room temperature in a Babcock centrifuge, after which the volume of cream was read with the aid of a light placed behind the bottle. Since each whole percentage division represents a volume of 0.1 ml., the percentage of cream is calculated by multiplying the whole percentage unit volume of cream by 0.1, dividing by the volume of milk used (35.2 ml.), and multiplying by 100.

Methods described in an earlier publication (25) were used for determining rennet curd tension, rennet coagulation time, and stability to alcohol. Determinations of pH values were made by the quinhydrone electrode method described earlier (23). Amounts of oxygen and of other gases were determined by means of the Van Slyke (31) manometric blood gas apparatus. The numbers of organisms in the kettle milks were determined by the standard plating method in tomato-milk powder agar, and the numbers in cheese were determined microscopically (2). The counts of mastitis streptococci were made in Edwards' blood agar medium.

In the cheese experiments, cheese was made in pairs from two weighed portions of the same lot of mixed milk, and each test cheese was made in the same manner as the control except for the experimental variations described. The clarifier used was of the old style and studies with the new no-foam clarifier were not made. The usual clarifying temperature was 28–30° C.

The internal diameter of the clarifier bowl was 204 mm. (8 inches), the capacity 4,000 pounds per hour, and the rated speed 7085 rpm. Each experimental cheese weighed 55–62 pounds when removed from the press. Curing conditions and details of grading were the same as those described earlier (24).

The starter culture used in the earlier experiments was 39a (now identified as *Lactobacillus lactis*). In later experiments, either B_2 (a culture of *Lactobacillus bulgaricus*) or Ga (a mixed culture of a lactobacillus with a mycoderma) was used. While the Ga culture has been used extensively in the manufacture of Swiss cheese in this country for a number of years, studies of the lactobacillus in this culture have not as yet shown it to be identical with any species of lactobacillus described in the literature. The later experiments included the use of *Streptococcus thermophilus* cultures in addition to the lactobacillus cultures referred to above.

A penetrometer was used for determining softness of body of cured cheese. It consisted of a cylindrical plunger one-eighth inch in diameter, with a flat end, mounted on a frame, surmounted by a 200-gram weight, and connected to a needle which moved on a dial graduated to show the movement of the plunger in hundredths of a centimeter. The distance that the plunger sank into a small block of cheese in 15 seconds was recorded, and the average of five determinations was taken as the penetrometer reading. Determinations were made at a constant temperature of 18° C., and also usually at two different temperatures so that changes in softness with temperature could be plotted.

EFFECTS ON PROPERTIES OF MILK

The average volume percentages of cream obtained on 12 pairs of samples of milk were as follows: Graduated cylinder method—clarified milk, 10.2; unclarified milk, 10.9; cream test bottle method—clarified milk, 9.8; unclarified milk, 10.9.

Measurements of the sizes of the fat globules determined microscopically in a large number of samples showed that the decrease in creaming could not be accounted for on the basis of a diminution of sizes of the globules. There was a slight increase following clarification in numbers of those more than 4 μ in diameter and a more evident increase of those more than 6 μ in diameter. Some relatively large globules (larger than 10 μ) were found much more frequently in clarified than in unclarified milk, and some of the largest globules were found to have apparently coalesced during clarification. The resulting clumbs were in some cases non-spherical in shape, and this effect was greater in milks clarified at 32° C. than in those clarified at 21° C.

It was found that the tendency of the fat globules to aggregate in clusters during creaming was reduced greatly by clarification. Data showing the effect of clarification on clustering and the effects of different modifications of the clarifying process on the numbers of clusters are shown in table 1. Counts in a large number of samples showed also an average reduction of about 20 per cent in the numbers of globules per cluster following clarification.

When cream that had been allowed to rise by gravity was clarified and remixed with the original skim milk it was found that the tendency of the fat to aggregate in the milk was reduced. A similar effect on clustering was produced when the gravity cream was agitated for 10 minutes at 40° C. and then remixed with the original skim milk.

TABLE 1

Effects of clarification and of other treatments of milk on average numbers of fat clusters in milk and on average extent of over-setting defect in Swiss cheese

Treatment of milk	Pairs of samples	Fat clusters per 0.01 cu. mm. milk		Eyes per cut surface of cheese	
		Number	Decrease in number	Number	Decrease in number
	number		*per cent*		*per cent*
Not clarified	30	186	......	106	......
Clarified	......	73	61	54	49
Clarifier speed 3500 rpm.	25	156	......	77	......
Clarifier speed 7000 rpm.	......	72	54	59	23
Clarified at 21° C.	26	134	......	73	......
Clarified at 32° C.	......	86	36	64	12
Gravity cream not clarified	16	173	......	98	......
Gravity cream clarified	......	92	47	65	34
Gravity cream untreated	10	172	......	118	......
Gravity cream heated and agitated	......	66	62	103	13

Results of the alcohol test showed that stability of milk proteins to alcohol is decreased slightly by clarification, indicating that the process alters the properties of the casein slightly.

The rennet coagulation time of milk was found to be unchanged following clarification. The rennet curd tension was not altered significantly. The pH value was usually unchanged, but in some instances was reduced slightly. The methylene blue reduction time at 37° C. was usually not changed materially but in some instances was decreased slightly.

In experiments in which 18 lots of mastitis milk were made into cheese (table 3), the average of the numbers of leucocytes was decreased by clarification from 2.4 millions to 0.7 million per milliliter, or about 70 per cent. The numbers of streptococci and of other bacteria were decreased also, but with less consistency and to a less extent. The percentage reduction in numbers of leucocytes tended to be greatest in those milks containing the largest numbers. The reduction varied directly with the speed of the clarifier bowl and with the temperature at which the milk was clarified, and inversely with the rate of flow of the milk through the clarifier.

Effects of clarification and of the addition of oxygen and of carbon dioxide upon the gas content of milk are shown in table 2. Clarification increased the oxygen content, decreased the carbon dioxide content, and decreased the total gas content. It will be noted that the interchange of gases resulting from clarification is in the same direction as that produced by the artificial introduction of oxygen, which has been shown by Marshall (12) and by us (16, 18) to have a favorable influence on the activities of desirable types of organisms in milk.

TABLE 2

Effects of clarification, and of treatment with gases, on the percentages of gases in milk

Treatment of milk	Pairs of samples	Duration of gas treatment	Average amounts of gases in milk			
			Oxygen	Carbon dioxide	Nitrogen and residual gases	Total
	number	*minutes*	*volumes per cent*	*volumes per cent*	*volumes per cent*	*volumes per cent*
Clarified	14	......	0.60	1.75	1.20	3.55
Not clarified	......	......	0.55	2.10	1.20	3.85
Oxygen added*	13	10	0.69	1.84	1.29	3.82
Normal	......	......	0.59	1.93	1.37	3.89
Carbon dioxide added*	7	5	0.52	3.58	1.22	5.32
Normal	......	......	0.58	1.84	1.24	3.66

* Gas bubbled through small openings in a perforated coil, at rate of 25 liters per minute, into 700 lb. milk in cheese kettle; temperature of milk, 28–30° C.; samples analyzed immediately after treatment.

Direct counts of Swiss cheese starter organisms made microscopically on five pairs of inoculated samples of milk that were subjected to the same temperature conditions existing in the cheesemaking process showed that the growth of the lactobacilli began considerably earlier in clarified than in unclarified milk and that the growth of both the lactobacilli and the streptococci progressed more rapidly in the former than in the latter. It was found also that, in milk samples held at 30° C., clarification caused the oxidation-reduction potential to decrease more rapidly.

EFFECTS ON QUALITY AND PROPERTIES OF CHEESE

Data for 369 pairs of cheese, showing the improvement of quality resulting from clarification and also the effects of various modifications of the clarifying process, are presented in table 3. In the cheese made from normal milk by the usual clarifying process (group 1), practically all of the im-

TABLE 3

Improvement in quality of Swiss cheese by clarification of milk, and effects of modifications of the clarifying process. (Averages for 60-lb. cheese cured 2½ to 3½ months)

Treatment of milk	No. of pairs	Scores of cheese* Eyes	Scores of cheese* Body and texture	Scores of cheese* Total	Proportion of cheese in each grade No. 1	Proportion of cheese in each grade Special	Proportion of cheese in each grade No. 2	Proportion of cheese in each grade Grinder
		points	*points*	*points*	%	%	%	%
1) Normal milk, clarified	112	25.4	23.0	75.2	49.1	34.8	9.8	6.3
Normal milk, not clarified	....	18.7	23.8	69.0	11.6	37.5	40.2	10.7
2) Mastitis milk, clarified	18	22.4	24.0	73.5	22.2	61.1	16.7	....
Mastitis milk, not clarified	....	12.2	23.2	61.2	5.6	11.1	22.2	61.1
3) Clarified	4	25.2	23.0	74.7	25.0	50.0	25.0	....
Separated	....	23.0	21.5	71.2	....	50.0	25.0	25.0
4) Clarifier speed—7000 rpm.	65	22.0	23.0	72.0	30.8	32.3	24.6	12.3
Clarifier speed—3500 rpm.	....	21.0	23.5	70.0	24.6	24.6	36.9	13.9
5) Clarified at 32° C.	63	23.8	22.7	73.2	44.5	23.8	23.8	7.9
Clarified at 21° C.	....	21.6	22.4	70.5	28.6	22.2	34.9	14.3
6) Normal rate of flow of milk through clarifier	16	24.2	22.4	73.6	31.3	37.5	25.0	6.2
Slow flow, half normal rate	....	25.2	23.8	75.6	50.0	31.3	12.5	6.2
7) Sediment from bowl returned to clarified milk	54	23.1	24.0	73.4	44.4	31.4	13.0	11.2
Milk clarified, sediment not returned to milk	....	23.2	22.0	71.7	29.6	29.6	29.6	11.2
8) 90-lb. gravity cream not clarified, 600-lb. gravity skimmilk clarified	36	17.6	23.1	67.7	5.5	36.1	27.8	30.6
90-lb. gravity skimmilk not clarified, rest of milk clarified	....	22.3	22.7	71.6	38.9	19.4	27.8	13.9
9) 90-lb. gravity cream clarified, 600-lb. gravity skimmilk not clarified	1	23.0	25.0	78.0	100.0	....	....	....
90-lb. gravity skimmilk clarified, cream and rest of milk not clarified	....	18.0	24.0	72.0	....	100.0	....	....

* Perfect score in points, according to scorecard used: eyes, 40; body and texture, 30; flavor, 20; and appearance, 10.

provement was in eye formation, *i.e.,* the eyes were larger, less numerous (less of the "oversetting" defect), shinier, and more regular and uniform in shape and distribution. There was a slight but uniform tendency toward more of the glaesler (curd-splitting) defect, and also more firmness of body, in the clarified than in the unclarified milk cheese. The former were generally slightly lighter in color and tended to rise somewhat more slowly in curing in the warm room. There were scarcely ever any detectable differences in flavor. Effects of different variations of the clarifying process upon the extent of the oversetting defect in the cheese are shown in table 1. The results show a striking correlation between the reduction in the fat clustering tendency in the milk, as affected by clarification, and the reduction in the oversetting defect in the cheese.

The greatest improvement resulting from clarification occurred when mastitis milk was used (group 2). Cheese made from this milk, without clarification, was wholly or partially pin-eyed (either pressler or nissler) in 15 instances out of 18. There were no pin-eyed cheese among those made from clarified milk. The unclarified, mastitis milk cheese was very soft or weak in body, relatively high in moisture content, and usually slightly inferior in flavor. Clarification caused an increase in firmness of body and a decrease in moisture content—factors which improve the quality of soft-bodied cheese.

Statistical tabulations of data for 110 wheels made from milks in which the leucocyte counts varied between 250,000 and 4,000,000 per milliliter showed a definite relationship between the numbers of leucocytes in the milks and the incidence and extent of the oversetting defect in the cheese. There was a strong tendency for high leucocyte counts in milk to be associated with "slow-working" or so-called "dead" milk in the kettle, with relatively slow development of acidity in cheese on the press, and with weakness of body in the cheese. These conditions are indicative of retardation of activity of starters and insufficient drainage of cheese on the press. They were improved markedly by clarification.

The use of the separator bowl did not produce as much improvement as the use of the clarifier bowl (group 3). In four experiments in which the milk was clarified twice, no additional improvement resulted from the second clarification. The improvement in quality was diminished when the speed of the bowl was decreased (group 4) and also when the milk was clarified at a relatively low temperature (group 5). The quality was improved when, with the bowl running at full speed, the rate of flow of milk through the bowl was diminished one-half (group 6). Results with the clarifier indicated that the improvement was generally proportional to the agitation or force to which the milk was subjected.

It is commonly believed that the improvement resulting from clarification is caused largely by the removal of extraneous matter or visible dirt.

However, the average quality of cheese made from clarified milk was found to be improved slightly, with respect only to the body, when the sediment from the bowl was returned to the clarified milk and mixed in thoroughly (group 7). Moreover, filtering the milk through cotton (12 pairs of cheese, unclarified milk) did not improve the quality of cheese to more than a very slight extent. Addition of the sediment did, however, cause a rather marked softening of the body of the cheese, which improved the body in this case because the cheese was ordinarily somewhat too firm; the average penetrometer reading on the cheese from clarified milk plus bowl sediment was 70; that on the normal controls, 45. The cheese to which the bowl sediment was added was also slightly more yellow and slightly less subject to the glaesler defect. The results indicated that improvement in eye formation cannot be ascribed to any great extent to the removal of visible sediment. It may be caused at least partially, however, by a change in the dispersion of the particles and by the effects of the process in breaking up bacterial clusters and distributing organisms more thoroughly in the milk, as Orla-Jensen (20) suggested.

Results of cheesemaking experiments with gravity cream (groups 8 and 9) indicated that effects of clarification on the fat in milk are apparently an important factor in improving the quality of cheese. When unclarified gravity cream (allowed to rise for 16 hours at 8–10° C.) was returned to the clarified milk (group 8), the quality of the cheese was so reduced as to make it comparable with that of cheese made from unclarified milk. When the gravity cream was clarified and then returned to unclarified gravity skim milk (group 9), improvement resulted which was comparable with that produced when all the milk was clarified. In further experiments made to determine effects of agitation on the fat, the gravity cream was warmed to 40° C., agitated vigorously for 10 minutes, and then re-mixed with the unclarified, gravity skim milk. This treatment resulted consistently in improvement in eye formation.

Prompted by results of Marshall (12) and of these laboratories (16, 18), referred to earlier, experiments were conducted to determine the effects of addition of oxygen and of carbon dioxide to milk. In 13 pairs of cheese the addition of oxygen (amounts shown in table 2) resulted in an average increase of six points in the scores of the test cheese. Twelve pairs were made with gaseous oxygen added to unclarified milk in the test kettle and with clarified milk in the control kettle. The average of the scores of the oxygen-treated, unclarified milk cheese was very nearly as high as that of the clarified milk cheese. Seven pairs were made from clarified milk with gaseous carbon dioxide added to the milk for the test cheese. The addition of carbon dioxide resulted in an average decrease of 10 points in the scores of the test cheese.

Results of counts of starter bacteria determined microscopically in samples taken from five pairs of cheese showed that the streptococci and the lactobacilli, particularly the latter, multiplied more rapidly in cheese made from clarified than in that made from unclarified milk. A pronounced decrease in numbers of lactobacilli began after the cheese was one day old, and this decrease was more rapid in the unclarified-milk than in the clarified-milk cheese. The numbers of streptococci diminished somewhat later and more slowly than the numbers of lactobacilli, and they also diminished more rapidly in the unclarified-milk cheese. At three hours after dipping the average pH value in 112 pairs of cheese was 0.03 lower, and at eight hours 0.10 lower, in cheese made from clarified milk than in that made from unclarified milk. In nearly every instance cheese made from clarified milk contained less lactose when one day old than that made from unclarified milk.

There was a consistent increase in firmness of body of cheese as a result of clarification. Averages of penetrometer readings at 18° C. for 70 pairs

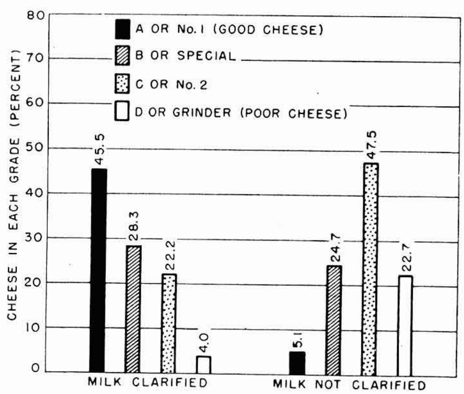

FIG. 1. Relationship between clarification of milk and quality of Swiss cheese (198 pairs of laboratory cheese).

of cured cheese made from normal milk were as follows: clarified, 35.1; unclarified, 55.0. Averages for 18 pairs made from mastitis milk were: clarified, 41.6; unclarified, 67.3. In many instances penetrometer readings were made at two or more temperatures and changes in softness were plotted against temperatures of readings. It was found that the clarified-milk cheese tended to soften less than the unclarified-milk cheese when the temperature was increased.

The glaesler (curd-splitting) defect occurred more commonly in cheese made from clarified than in that made from unclarified milk; the average difference in score for this defect was 0.5 point.

Averages of composition, yield, and fat loss data for 150 pairs of uncured cheese were as follows: clarified—moisture, 38.56 per cent; fat in dry matter, 47.7 per cent; yield, 9.65 per cent; fat in whey, 0.67 per cent; unclarified—

moisture, 39.19; fat in dry matter, 48.4; yield, 9.82; and fat in whey, 0.62. The decrease in yield resulting from clarification was apparently slightly greater than could be accounted for by the observed decrease in moisture content and the slight increase in fat loss in the whey. The lower moisture content in clarified milk cheese is undoubtedly of some importance in improving the quality, since it has been shown (24) that high moisture content is one of the factors responsible for inferior quality.

Data for 198 pairs of Swiss cheese, showing the average improvement in quality in our experiments, are presented in figure 1. A photograph illustrating the typical improvement in eye formation resulting from clarification of normal milk is presented in figure 2. The use of the clari-

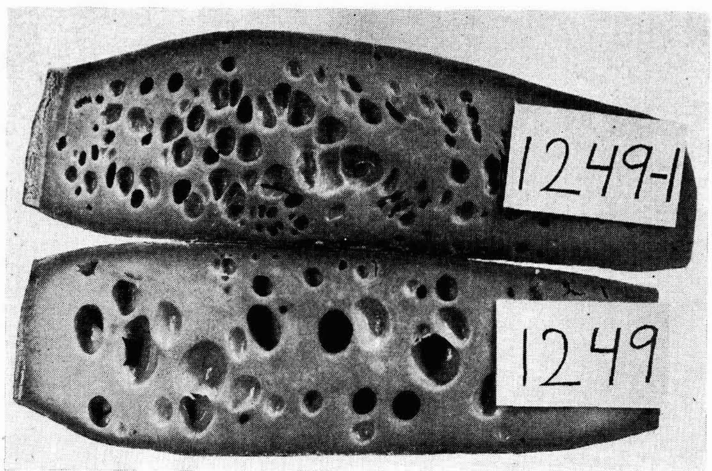

FIG. 2. Effect of clarification in improving the quality of Swiss cheese. No. 1249–1, milk not clarified. No. 1249, milk clarified.

fying process with normal milk increased the average grade from No. 2 to Special.

DISCUSSION

Although the removal of the extraneous matter is generally believed to be important in improving the quality of Swiss cheese, it was found in these experiments that the return of the bowl sediment to clarified milk did not injure significantly the eye formation of the cheese, although it tended to result in cheese of softer texture. The extent of leucocyte removal (about 70 per cent) by clarification was in agreement with the work of earlier investigators. The pronounced decrease in number of leucocytes, considered in conjunction with the fact that clarification resulted in an increase in the growth of the starter organisms in milk and in cheese, has suggested the possibility that one factor responsible for relatively poor quality in unclarified-milk cheese made from milk having mastitic characteristics may be the inhibition or partial destruction of starter organisms by leucocytes. Whitehead and Cox (32) presented data which they believed indicated evidence of ability of leucocytes, particularly if present in large numbers, to retard the activity of lactic acid bacteria by phagocytic ingestion. In our work, however, microscopic examination of starter organisms grown in unsterilized, mastitis milk showed what appeared to be inconclusive evidence of phagocytosis of the lactobacilli by the leucocytes. The increase in acid development in cheese eight hours after dipping, resulting from clarification, indicates that some factor present in mastitis milk and partially removed or altered by the clarifier has a retarding effect on the growth of the lactobacilli.

The factor of agitation appears to be responsible for many of the changes resulting from clarification of the milk. Possibly, foremost among these changes is the dispersion and alteration of the fat. Results of other investigations, mentioned above, have shown that preliminary clustering of milk fat is essential to normal creaming. Our results indicate that the decrease in creaming in clarified milk is attributable primarily to a decrease in the clustering tendency. The evidence available agrees with the explanation of Hekma (8) that the change in the clustering tendency following clarification or agitation of milk results from a decrease in the amount of agglutinating material adsorbed on the surfaces of the fat globules.

Whether the improvement in the cheese following the clarification of the milk or the clarification or agitation of the gravity cream results in any degree from the reduction in the tendency of the fat to aggregate has not been determined. It is possible that when there are more large aggregates of fat, such as occur in unclarified milk, these clusters of fat may form "weak" areas in the cheese curd. Any such fat clusters containing foreign particles, which may be picked up from the milk and which are likely to contain unusually large numbers of gas-producing organisms (6), may serve as foci for abnormal eye formation in the cheese.

While the results of the experiments on the clarification and agitation of only the gravity cream indicated that the physical effect is largely on the fat, it cannot be concluded definitely that the beneficial effects are not also partially bacteriological—the breaking up and distributing of chains and clusters of organisms. Stine (29) has shown that when cream rises on milk the organisms tend to be carried upward with the fat and their numbers per milliliter in the cream layer may be 50 times as great as in the skim milk below. Schmidt (26) found an 85-fold proportion of *S. lactis* in the cream layer.

The results described above on the interchange of gases occurring during clarification and on the effects of adding oxygen and carbon dioxide to cheese milk indicate that the effect of the process on the amounts of these gases in milk is an important factor in controlling the type of bacterial fermentation in a manner favorable to the proper ripening of the cheese.

The cheese made from clarified mastitis milk was of unusually high quality in view of the known disadvantages in the use of such abnormal milk for cheesemaking. It should be explained that the milk received regularly for this experimental work was from a herd having a rather large proportion of Jersey cows. The normal milk was therefore relatively high in solids content and the cheese made from it was relatively firm and of slightly poorer quality generally than would be expected from milk containing less solids. The effect of clarification on the experimental cheese resulted in greater improvement in the case of mastitis milk than in the case of normal milk.

The milk received in the factories, however, comes from herds which consist largely of Holsteins or of cows belonging to other breeds that produce milk of relatively low solids content. The cheese made in most factories is less firm and often tends to have a soft texture and even a weak body. The additional softening of the body resulting from mastitic characteristics of the milk is likely, on the basis of these results, to be particularly detrimental if the milk is not clarified.

SUMMARY

Experiments have demonstrated that clarification of milk produces a marked and consistent improvement in the quality of Swiss cheese. Studies were conducted of the properties of the cheese milk for the purpose of investigating the intermediate factors in the improvement in the cheese. Specific effects of clarification on milk include a decrease in the tendency of the fat to form aggregates upon standing, removal of a large proportion of the leucocytes from mastitis milk, an increase in the rate of multiplication of starter organisms and improvement in results of fermentation tests, an increase in concentration of oxygen and decrease of carbon dioxide, an increase in the rate at which the oxidation-reduction potential changes at 30° C., and a slight decrease in stability to alcohol.

Specific effects of the process on the properties of the cheese include a marked decrease in number and increase in size and uniformity of eyes, an increase in the firmness of the cheese and in the incidence of the glaesler defect, an increase in the rate of multiplication of starter organisms and of acid formation, a decrease in moisture content and in yield of cheese, and an increase in the fat loss in the whey.

The effects of clarification on properties of milk and on properties and quality of cheese were found to be diminished by clarifying the milk at a relatively low temperature and with a relatively slow bowl speed; they were increased by decreasing the rate of flow of milk through the bowl by

one-half, and by increasing the temperature from 21° to 32° C. The beneficial effects of clarification of milk for cheesemaking were especially pronounced in the case of mastitis milk.

Of the intermediate factors in the improvement of quality of clarified milk cheese, those that appear most significant are a decrease in aggregation of the fat globules, an increase in oxygen and decrease in carbon dioxide, improvement in effectiveness of starters, and a reduction in leucocytes when present in large numbers.

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PREVENTION OF MILKSTONE FORMATION IN A HIGH-TEMPERATURE-SHORT-TIME HEATER BY PREHEATING MILK, SKIM MILK AND WHEY

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In the course of experiments on high-temperature short-time forewarming of milk (6) it was observed that, when the milk was reheated, the pressure required to force the liquid through the heating, holding and cooling coils was nearly constant, whereas when raw milk was heated in this equipment more and more pressure was required to maintain a constant flow. This observation seemed of such practical value as to justify an investigation of the conditions under which the effect could be obtained, and an explanation of the cause.

EXPERIMENTAL

The equipment was, in general, the same as that described in a recent paper (6). The pump was the reciprocating type. It operated at 200 strokes per minute and had a capacity of 90 gallons per hour. The internal diameter of the stainless steel tubing through which the liquid was pumped at the uniform rate of flow of 22 feet per second was 0.18 inch. Three seconds were required to heat and 3 seconds to cool the liquid. When the holding time was 15 seconds, the total length of the tubing from the pump to the outlet at the end of the cooling coil was about 480 feet. The pressure required to pump water through this length of clean tubing at the rate of 90 gallons per hour was 2,000 pounds per square inch. The resistance to flow of more viscous liquids was, of course, greater. Under uniform conditions an operating pressure greater than that required when the tubing was clean was considered due to a coating of milk solids or the formation of "milkstone" on the inside wall of the tubing.

It is apparent that, under the above conditions, even a very thin deposit on this tubing would be reflected in the amount of force or pump pressure required to maintain a uniform flow of liquid.

When raw milk at room temperature was pumped through the system without heating there was no increase over the initial operating gage pressure.

Preheating a test liquid other than in the high-temperature equipment was done in steam-jacketed hotwells equipped with agitators. In one hotwell it was the practice to heat 40 gallons of liquid; in the other, 50 gallons. The period required to attain the desired temperature was approximately the

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same in each hotwell. To heat from 10° C. (50° F.) to 65° C. (149° F.) took 28 minutes; to 75° C. (167° F.), 33 minutes; to 85° C. (185° F.), 40 minutes; and to 95° C. (203° F.), 48 minutes. The 40 gallons of milk, skim milk or whey were cooled by pumping over a surface cooler at the rate of 2 gallons per minute. From the other hotwell the 50 gallons of milk were drawn into a vacuum pan in 6 minutes, where 10 minutes elapsed before the temperature of the vapor over the boiling milk was lowered to 40 (104° F.) to 45° C. (113° F.).

To determine the effect of a preheating treatment on the rate of development of milkstone, the preheated material was heated in the clean, high-

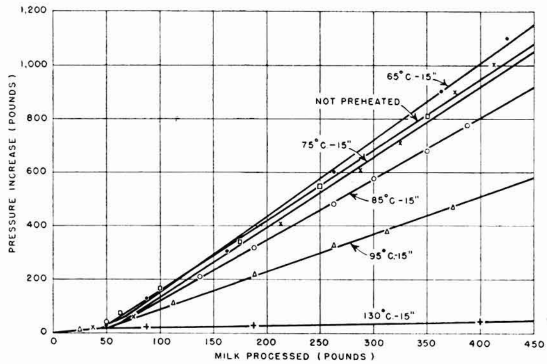

FIG. 1. Effect of preheating treatment of whole milk on the rate of pump pressure increase due to milkstone formation when the preheated milk was heated at 130° C. for 15 seconds by pumping it through heating, holding and cooling coils of 0.18 inch internal diameter. Preheating treatment is shown on each curve. Rate of milkstone formation is expressed as pounds per square inch increase in resistance to flow per pound of milk processed.

temperature equipment in 3 seconds to 130° C. (266° F.), maintained at this temperature for 15 seconds, and cooled in 3 seconds.

In making this determination, water was heated in the equipment first. When the desired temperature conditions had been established a 2-way valve was turned so that the test liquid, instead of water, would flow to the pump. One minute after this liquid began to pass into the pump the first pressure reading was noted. Additional gage readings were recorded from time to time. The last pressure gage reading was made just before the valve was turned to again admit water. The difference between the first and last readings on the pressure gage was considered the total increase in pressure.

The fresh whole milk was standardized by the Babcock test and a hydrometer reading (2) to a fat: solids-not-fat ratio of 1: 2.29.

The whey was the low acid or rennet type. It was prepared from fresh skim milk by the addition of rennet and clarified.

RESULTS

In figure 1 are shown increases in pressure gage readings due to milkstone formation on heating raw milk (not preheated) to 130° C. for 15 seconds and milk to the same temperature and for the same holding period that had been preheated in the high-temperature-short-time equipment at 65, 75, 85, 95, and 130° C. for 15 seconds. As the preheating temperature was increased less solids were deposited on the tubing. When milk that had been heated at 130° C. for 15 seconds was reheated under the same conditions only a small amount of milkstone formed.

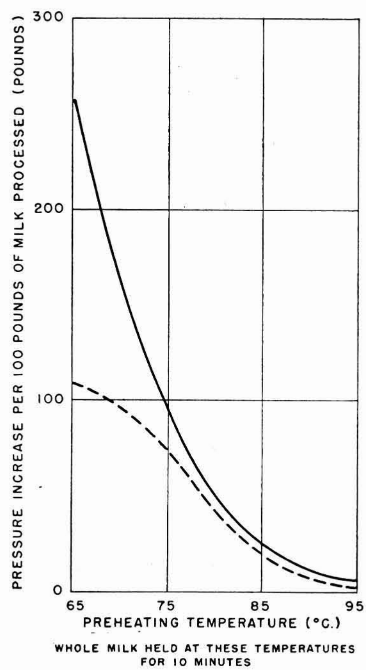

FIG. 2. Effect of preheating treatment of whole milk on the rate of pump pressure increase due to milkstone formation when the preheated milk and condensed milk made from it were heated at 130° C. for 15 seconds by pumping them through a high-temperature tubular heater. Solid line represents whole milk, broken line homogenized condensed milk of 26.0% solids content. Rate of milkstone formation is expressed as pounds per square inch increase in resistance to flow per hundred pounds of whole milk processed.

The effect of different preheating treatments of whole milk on the rate at which milk solids adhered to the tubing is shown in figure 2. In these experiments both fluid whole milk and its concentrate of 26 per cent solids content were used. The concentrated milk was homogenized at 60° C. (140° F.) and 2,500 pounds pressure before the final or test heating at 130° C. for 15 seconds.

As the preheating temperature was increased the rate at which the tubing became coated with solids decreased until, with a preheating temperature of 95° C. and a holding period of 10 minutes, the rate was slow.

In terms of whole milk equivalents, solids in the concentrated milks adhered to the tubing at a slower rate than did the solids in the preheated whole milk. However, in terms of pounds of concentrated milk processed

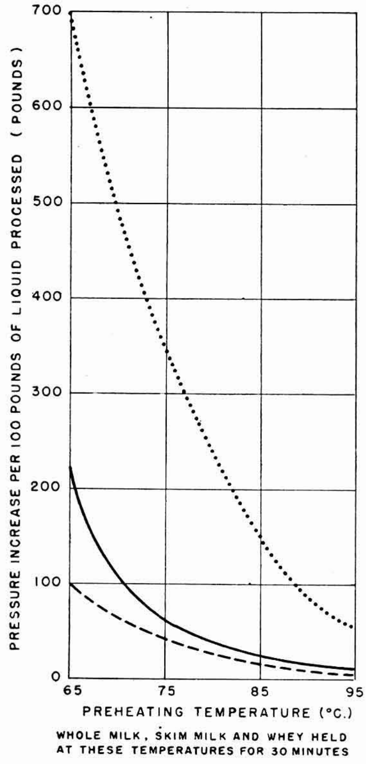

FIG. 3. Effect of preheating treatment of whole milk, skim milk and whey on the rate at which the pump pressure increased due to milkstone formation when the liquids were heated at 130° C. for 15 seconds. Solid line represents whole milk, broken line skim milk, and dotted line whey.

the rate was much faster except when the preheating temperature was below about 70° C. (158° F.) and above 90° C. (194° F.)

In obtaining the data shown graphically in figure 3 the same procedure was followed as in obtaining the data presented in figure 2 for whole milk except that skim milk and whey were used as well as whole milk and the holding period at each preheating temperature was 30 minutes.

DISCUSSION

The formation of milkstone on dairy equipment has received much attention. It makes the transfer of heat more difficult; the deposit is insanitary, is deleterious to the metal, and must be removed. Shere (5) has described this deposit and recommends methods for removing it. He shows that its composition varies but that it is organic matter mixed with small quantities of substances which contain calcium and phosphorus.

An effective procedure for cleaning the tubing of the high-temperature-short-time equipment was to recirculate continuously through it a solution of hot trisodium phosphate and then, after flushing with water, a solution of citric acid. The pH of the former was about 11.5 and of the latter, about 2.0. In this way a large reduction in pressure was obtained in a few minutes and then, when the acid was recirculated continuously, soon there was a return to the pressure which was normal for forcing the liquid through clean tubing. If the acid was used first, only a small reduction in pressure was obtained, and usually only after a relatively long time. Finally when the acid was followed by the alkali, the tubing was cleaned quickly. This indicates that the milkstone was largely organic mixed with small quantities of inorganic matter. The proteins of milk are more soluble at pH 11.5 than at pH 2.0 and calcium phosphates are soluble at pH 2.0 but not at pH 11.5.

It is interesting to compare the relationship between the preheating treatments and the formation of milkstone with the heat denaturation of the soluble milk proteins, albumin and globulin.

Rowland (3, 4) made an investigation of the amounts of lactalbumin and lactoglobulin denatured (rendered insoluble) by heating portions of the same milk for varying periods at each of several temperatures. He found that appreciable quantities of albumin and globulin are denatured at as low a temperature as 63° C. (145° F.). In the summary of his first article he says, "Smooth curves were obtained for the progress of denaturation with time at each temperature, and, over the range of 63–75° C., the relative increase in velocity of denaturation for each rise in temperature of 1° C. was found to be constant, the temperature coefficient of the reaction being 1.5."

In the summary of his second article Rowland states, "The denaturation of albumin and globulin took place rapidly in samples of milk heated at temperatures of 75° C. and above, and was complete in approximately 60, 30, 10–15, and 5–10 minutes at 80, 90, 95, and 100° C., respectively."

Bell (1) studied the effect of heat on the solubility of the calcium and phosphorus compounds in milk. From his results he concluded that ". . . there is a loss in the soluble calcium and phosphorus contents of the skim milk due to heat and that the amount of the loss depends upon the temperature to which the milk has been heated.

"The results from the methods employed indicate that definitely measurable amounts of these substances are removed from solution in milks heated to 170° F. or above."

In view of the time-temperature conditions required to denature all the albumin and globulin in milk as shown by Rowland, the continued removal of calcium and phosphorus from solution due to heat as reported by Bell, and the results described in this paper, it seems probable that the formation of milkstone in a high-temperature-short-time heater can be practically prevented by suitable preheating of milk, skim milk and whey.

SUMMARY

1. The formation of milkstone in a high-temperature-short-time heater was greatly decreased by preheating milk, skim milk and whey.

2. There appears to be a direct relationship between the heating conditions which render insoluble some of the proteins and salts of milk and the prevention of milkstone formation.

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White, G. C.
Yale, M. W.

JOURNALS

American Butter Review
American Milk Review
American Journal of Diseases of Children
American Journal of Physiology
American Journal of Public Health
Archives of Pediatrics
Australian Journal of the Council for Scientific and Industrial Research

Biochemical Journal

Canadian Dairy and Ice Cream Journal
Canadian Journal of Public Health
Canadian Journal of Research
Certified Milk
Cornell Veterinarian

Dairy Industries
Dairy World

Endocrinology

Food in Canada
Food Industries
Food Manufacture
Food Research

Ice and Refrigeration
Ice Cream Field
Ice Cream Review
Ice Cream Trade Journal
Industrial and Engineering Chemistry

Journal of Agricultural Research
Journal of Agricultural Science
Journal of American Medical Association
Journal of American Veterinary Medical Association
Journal of Animal Science
Journal of Bacteriology
Journal of Biological Chemistry
Journal of Dairy Research
Journal of Dairy Science
Journal of Endocrinology
Journal of Experimental Medicine
Journal of General Physiology
Journal of Genetics
Journal of Heredity
Journal of Industrial and Engineering Chemistry
Journal of Infectious Diseases
Journal of Milk Technology
Journal of Nutrition
Journal of Pathology and Bacteriology
Journal of Physical Chemistry
Journal of Physiology
Journal of Veterinary Research

Lancet
Le Lait

Milk Dealer
Milk Industry
Milk Plant Monthly

National Butter and Cheese Journal
New Zealand Journal of Science and Technology

Oil and Soap

Pacific Dairy Review
Proceedings of Society of Experimental Biology and Medicine

Refrigerating Engineering

Scientific Agriculture
Southern Dairy Products Journal

SPECIAL PUBLICATIONS

Federal Dairying and Bacteriological Establishment, Liebefeld, Berne, Switzerland

International Association of Ice Cream Manufacturers
International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

190. **Simple Multiple-Loop Method Speeds Bacterial Counts.** ANDREW MOLDAVAN, Pure Milk Co., Montreal, Canada. Food Indus., *15,* No. 6: 56. June, 1943.

The author states that plate counts are time-consuming. In order to simplify bacteria estimates a modified Myers-Spence procedure is described. It involves using a loop and melted cooled nutrient agar. Thus the operator is given a chance to do many determinations with a minimum of effort.

The apparatus is described. Loop and pipette accuracy is discussed, including a method for calibrating the loop with a 0.01-ml. pipette.

J.C.M.

191. **Research Finds Substitute for Bacteriological Agar.** W. E. BAIER AND T. O. MANCHESTER, Ontario. Food Indus., *15,* No. 7: 94. July, 1943.

A shortage of agar has caused investigators to search for a substitute for bacteriological agar. As a result, a pectinous material, sodium ammonium pectate, has been used successfully in some of the most commonly employed solid media.

Culture media for plates and slants, particularly counting plates considered here, demand a gel-producing constituent which meets very exacting specifications. Other gel materials have been suggested and some have been used in special applications, but agar has been and still remains the standard gel-forming agent for bacteriological culture media.

The article gives formulae for making the substitutes for agar for milk work. Details are given for using the substitute for agar. J.C.M.

CHEESE

192. **New Way to Dehydrate Cheese.** GEORGE P. SANDERS, U.S.D.A., Washington, D. C. Food Indus., *15,* No. 10: 80. Oct., 1943.

American cheddar cheese usually contains more than 33% water, removal of which would reduce the weight by at least one-third, and would also make it possible to compress the cheese into a smaller volume. These savings are important under wartime shipping and storage conditions, and therefore the commercial dehydration of cheese has been undertaken.

Under the new method, which is applicable to any type of hard cheese, only properly cured cheese, selected with particular attention to flavor, and thoroughly cleaned, should be used. This is blended as in the manufacture of process cheese. The subsurface portion of the rind, if clean and edible, can be used in the blend.

The author gives details of drying and compressing. Uses and quality as affecting the process are discussed. The author feels that the laboratory successes deem a commercial trial as being desirable. J.C.M.

CHEMISTRY

193. Chromatographic Determination of Carotene in Alfalfa. L. W. CHARKEY AND H. S. WILGUS, JR., Colo. Agr. Expt. Sta., Fort Collins, Colo. Jour. Indus. and Engin. Chem., Analyt. Ed., *16,* No. 3: 184. Mar., 1944.

Three important factors may cause errors in the determination of carotene in plant tissues. There may be oxidative losses of carotene, errors due to incomplete extraction from the tissue or incomplete separation of carotenes from other pigments. The chromatographic method described in this report, supported by experimental data, avoids these sources of error. The method includes an enzyme inactivation and sample storage procedure, making possible the collection and preparation of large numbers of samples on fixed dates. The chromatographic technique was modified by converting the adsorption column to an adsorption filter which avoided losses of adsorbed carotene. B.H.W.

194. Yeast Microbiological Methods for Determination of Vitamins. Pantothenic Acid. LAWRENCE ATKIN, WILLIAM L. WILLIAMS, ALFRED S. SCHULTZ, AND CHARLES N. FREY, Fleischmann Labs., Standard Brands, Inc., New York, N. Y. Jour. Indus. and Engin. Chem., Analyt. Ed., *16,* No. 1: 67. Jan., 1944.

Pantothenate is determined by adding an extract of the unknown to 5 ml. of basal pantothenic acid-free medium in a test tube, heating, then cooling and inoculating the tubes with 1 ml. of the yeast, *Saccharomyces carlsbergensis.* The tubes are shaken at 30° C. for 16 to 18 hours and the yeast growth is estimated by turbidimetric measurements made directly on the tubes with the photoelectric colorimeter. The basal medium contains ammonium sulfate as a nitrogen source and in addition sufficient asparagine to prevent interference due to B-alanine. Extracts of substances to be assayed are prepared by aqueous extraction under pressure (15 pounds for 15 minutes) at pH 5.6 to 5.7, by enzyme digestion at the same pH, or by enzyme digestion followed by aqueous extraction (15 pounds for 15 minutes). The choice of extraction method depends upon the substance, since some have pantothenate in a bound form whereas others do not. The results of assays of a number of substances including pasteurized milk, dry skim milk and whey compare favorably with results obtained by other methods.

B.H.W.

195. Quantitative Determination of d-Galactose by Selective Fermentation with Special Reference to Plant Mucilages. LOUIS E. WISE AND JOHN W. APPLING, Inst. of Paper Chemistry, Appleton, Wis. Jour. Indus. and Engin. Chem., Analyt. Ed., *18,* No. 1: 28. Jan., 1944.

A method is described which permits the determination of small amounts of d-galactose in the presence of mannose, glucose, fructose, xylose, arabinose and glucuronic acid with an accuracy of 92% to 98%. It depends on differential fermentations with two yeasts, *Saccharomyces carlsbergensis* which ferments galactose and *S. bayanus* which does not ferment galactose. The yeasts have little effect on xylose, arabinose or glucuronic acid. The reducing values of galactose, mannose and d-glucurone were determined by the Munson-Walker method. The fermentation techniques were successfully applied to the hydrolysis products of pure lactose and certain plant mucilages.

B.H.W.

196. Determination of Vitamin A and Carotenoids in Butterfat. Spectroscopic Characteristics of Butterfat Fractions and Problems Involved in Biological Interpretations. F. P. ZSCHEILE, R. L. HENRY, J. W. WHITE, JR., H. A. NASH, C. L. SHREWSBURY, AND S. M. HAUGE, Purdue Univ. Agr. Expt. Sta., Lafayette, Indiana. Jour. Indus. and Engin. Chem., Analyt. Ed., *16,* No. 3: 190. Mar., 1944.

Butterfat samples produced under different dietary conditions were studied by the direct spectroscopic method. Total carotenoids were estimated and ultraviolet measurements were made on the unsaponified fraction. Curves of the total carotenoids and of the carotene fraction from a series of butters were compared with that of β carotene. Corresponding curves of the unsaponifiable fraction in the ultraviolet region were compared with that of vitamin A. Effects of clarification, adsorption, acid extraction, and freezing upon the curves were studied, as well as various factors affecting the reliability of the experimental procedures. No clear-cut relationships could be established as a result of attempts to correlate spectroscopic and biological values. The feed of the cows had a great influence on the nature of the carotenoids present in the butterfat. There should be more extensive purification of the vitamin A fraction for the successful application of direct spectrophotometry to the determination of vitamin A in butterfats.

B.H.W.

197. Fatty Acid Monoesters of l-Ascorbic and d-Isoascorbic Acids as Antioxidants for Fats and Oils. R. W. RIEMENSCHNEIDER, J. TURER, P. A. WELLS, AND WALDO C. AULT, Eastern Regional Res. Lab., U. S. Dept. of Agr., Philadelphia, Pa. Oil and Soap, *21,* No. 2: 47. Feb., 1944.

Fatty acid monoesters of l-ascorbic and d-isoascorbic acids were found to have antioxygenic activity in fats and oils. These substances were found to counteract the deleterious effect of traces of soap on the stability of fats. In combination with either α-tocopherol or phospholipids or both, the ascrobyl monoesters exhibit marked synergistic antioxidant effect. Postulations as to the cause of synergistic phenomena are presented. J.L.H.

198. The Antioxidant Properties of Nordihydroguaiaretic Acid. W. O. LUNDBERG, H. O. HALVORSON, AND G. O. BURR, Univ. of Minn., Minneapolis. Oil and Soap, *21,* No. 2: 33. Feb., 1944.

The antioxidant properties of nordihydroguaiaretic acid in lard are described. This phenolic-type inhibitor was obtained from a common desert plant (*Larrea divaricata*). Nordihydroguaiaretic acid exhibited synergistic action with ascorbic acid but not with a wheat germ concentrate containing 40% of mixed tocopherols. The effectiveness of the antioxidant in stabilizing lard is to some extent carried over into baked products (pie crusts).

J.L.H.

199. Formation and Decomposition of Peroxides of Unsaturated Fat Esters. R. F. PASCHKE AND D. H. WHEELER, U. S. Regional Soybean Industrial Products Lab., Urbana, Ill. Oil and Soap, *21,* No. 2: 52. Feb., 1944.

The influence of temperature on the formation and decomposition of peroxides of unsaturated fat esters (distilled methyl esters of soybean fat acids) was investigated. The curves of decrease of iodine value and increase in peroxide value were found to parallel each other in the early stages of the reaction. As the temperature of oxidation increased above 35° C., the lower was the level at which the curves deviated and the lower the maximum peroxide value attained. At 15° and 35° C. the same maximum of peroxide values was observed, and at this point the value obtained was approximately 30% of what it would be if all the double bonds destroyed were converted to peroxides. The speed of decomposition of peroxides became progressively greater as the degree of oxidation increased. The rate of decomposition or disappearance of peroxide was found to agree best with that of a bimolecular reaction but definite exceptions were observed.

Investigation of reaction time and effect of oxygen on the determination of peroxides by the acetic acid-potassium iodide method, showed that a one-hour reaction time in the absence of oxygen was necessary, especially on samples of high peroxide content. J.L.H.

200. The Fluorescence of Chlorophyll in Fats in Relation to Rancidity. C. S. French and W. O. Lundberg, Univ. of Minn., Minneapolis, Minn. Oil and Soap, *21,* No. 1: 23. Jan., 1944.

The "chlorophyll value" as a measure of the keeping quality of oil was investigated. According to theory the color change was due to the "quencing" of the chlorophyll fluorescence by the transfer of excitational energy from chlorophyll molecules to acceptor molecules contained in the fat.

It appears that the disappearance of chlorophyll fluorescence in ultraviolet light is due to the absorption of the light by the cottonseed oil and to the intense white fluorescence of the oil itself rather than to a chemical reaction of some constituent of the oil with the excited chlorophyll. The lack of correlation between either the peroxide value or the conventional stability measurements and amount of chlorophyll fluorescence in the fats used makes the "chlorophyll value" test "appear to have doubtful value as a generally applicable test for fat rancidity or stability."

The absorption of near ultraviolet light by oxidized fats may be related to their content of fat peroxides. J.L.H.

201. The Use of Refractive Index Measurements in Fatty Acid Ester Analysis. Karl F. Mattil and Herbert E. Longenecker, Univ. of Pittsburgh, Pittsburgh, Pa. Oil and Soap, *21,* No. 1: 16. Jan., 1944.

The determination of the composition of fats and oils is usually accomplished by the fractional distillation of their mixed methyl esters and the analysis of the separated fractions. When packed columns are used, fractions containing not more than two adjacent homologous components can be obtained. The fractions can then be analyzed for composition by the use of simultaneous equations based on the saponification equivalent, the iodine value and the thiocyanogen value. Two inherent difficulties of the method are, (a) the accuracy with which the analytical constants must be determined and, (b) the small size of certain fractions (0.1 to 0.2 grams).

The linear relationship that exists between the refractive index and the composition of a mixture of adjacent homologous methyl esters makes it possible to use the index as a tool in the calculation of the composition of unknown mixtures. For precise work it is necessary to use a refractometer where the fifth decimal can be estimated and where the temperature can be controlled or known to a few hundredths of a degree. One important advantage of the method is that the analysis can be completed soon after the fraction is taken from the column. J.L.H.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

202. **Compressing Spray-Dried Milk to Save Shipping Space.** B. H. WEBB AND C. F. HUFNAGEL, U. S. Dept. of Agr., Washington, D. C. Food Indus., *15,* No. 9: 72. Sept., 1943.

Studies show that as much as 42% of the space occupied by dried milk can be saved by compression, 24% by jolting. Milks subject to different manufacturing conditions, however, may vary widely in their compression characteristics.

Important savings in the amount of shipping space taken up by spray-dried milk can be attained by compression and by jolting or bumping in wartime packaging operations. The savings in space effected by compression may be expected to range from approximately 21% for compression in a small package at a pressure of 500 lb. per square inch to 42% for die compression at 3,200 lb. per square inch. Jolting may be expected to save 11% of the space in a bulk package and 24% in a small package.

The details of both procedures are given, and the advantages listed.

J.C.M.

203. **Removal of Oxidizing Factors Makes Dry Whole Milk Keep.** C. D. DAHLE AND D. V. JOSEPHSON, Penn. State College, State College, Pa. Food Indus., *15,* No. 11: 76. Nov., 1943.

Whole milk powder can be treated in processing so as to remove pro-oxidant constituents which make it subject to oxidized or tallowy flavor. The product then has excellent keeping qualities and should satisfactorily meet present requirements.

That whole milk powder develops a stale oxidized flavor after some weeks or months of storage is a fact which has hindered this product from gaining wide acceptance. But the present war has focused attention again on dried whole milk because huge amounts are purchased by the military and lend-lease authorities. No doubt it will prove to be in great demand, even after actual fighting stops.

The authors feel that oxidation of dried whole milk can be improved when better procedures are available to do on a large scale these things which were achieved in a laboratory. J.C.M.

ICE CREAM

204. **Conserving Milk Solids.** J. H. ERB, The Borden Co., Columbus, Ohio. Ice Cream Trade Jour., *40,* No. 3: 20. March, 1944.

It is pointed out that considerable improvement in the quality of "wartime ice cream" is possible, without the substitution of cereal products for lacking milk solids, if the manufacturer makes use of present knowledge and gives close attention to each step of processing. The following suggestions are made:

Superheated condensed milk should be used rather than unsuperheated, and frozen condensed milk should be avoided. Efficient homogenization is very important. Low solids mixes should be aged 24 hours. The proper quantity of a good stabilizer should be used and it should be handled to get the maximum benefit from it. Mix should be quickly frozen to as stiff a consistency as possible and hardening should be rapid. F.J.D.

205. **Velva Fruit—A New Frozen Fruit Dessert.** H. J. LOEFFLER, Western Regional Res. Lab., U.S.D.A., Albany, Calif. Ice Cream Trade Jour., *40,* No. 3: 16. March, 1944.

The author describes a new frozen dessert made from fruit purees. The name "Velva Fruit" is suggested to distinguish the new product from ices and sherbets. Suitable purees can be prepared from a large number of different fruits and some blends. The whole, fleshy, fruit is used in preparing the purees which may then be frozen for distribution to the manufacturer, or they may be used without freezing if kept cold and utilized in a relatively short time.

To the puree is added sugar, gelatin and perhaps citric acid if the fruit is not sufficiently tart. The amount of sugar is varied somewhat with the sweetness of the fruit and about 0.6% of gelatin is usually required. The mixture is frozen in ice cream equipment to approximately 100% overrun. Several formulas are given.

"Velva fruit" differs from ices and sherbets in that the fruit solids and juice account for 60% of the finished product as compared with about 20% where the fruit is used primarily as a flavor. The overrun is also considerably higher but the extra fruit solids prevent excessive fluffiness. "Velva fruit" melts somewhat slower than ice cream but has similar body or dipping qualities at similar temperatures. F.J.D.

206. **An Excess Solids Method for Calculating Ice Cream Mixes.** ALAN LEIGHTON, Bur. of Dairy Indus., Washington, D. C. Ice Cream Rev., *27,* No. 3: 24. Oct., 1943.

The author has worked out a variation of the serum point method for calculating ice cream mixes. This method uses the water content of the mix and dairy products, instead of their serum as the reference medium. The method is explained in detail with examples. J.H.E.

207. **Use of Whey Solids in Ice Cream and Sherbets.** ALAN LEIGHTON, Bur. of Dairy Indus., Washington, D. C. Ice Cream Rev., *27,* No. 6: 18. Jan., 1944.

Whey solids from Cheddar cheese whey was used in experimental ice cream mixes to replace varying percentages of serum solids. In the case of

10% butterfat and 8% serum solids mixes, 1.6% of whey solids could be substituted with no detriment to quality.

When whey solids were added to mixes to raise the total solids content there was marked improvement in body and texture. No undesirable flavors were noted.

The experiments indicated that whey solids could be used advantageously in wartime ice cream.

Sherbets in which whey solids were used in place of normal milk-solids-not-fat were not noticeably different from the controls.

When using liquid whey it should be pasteurized to inactivate the rennet and thus avoid coagulation. J.H.E.

208. Merchandising Ice Cream in War Time. GEO. W. HENNERICH, Ice Cream Merchandising Inst., Washington, D. C. Ice Cream Rev., *27*, No. 3: 70. Oct., 1943.

The idea is expressed that ice cream merchandising is needed now more than ever. A program of merchandising must be carried out that will keep consumer interest in ice cream until consumer demand can again be supplied. J.H.E.

209. Quince Seed Extract as an Ice Cream Stabilizer. GIDEON HADARY AND H. H. SOMMER, Univ. of Wis. Ice Cream Rev., *26*, No. 11: 22. June, 1943.

The properties of quince seed water extract as a stabilizer for ice cream have been studied and compared with those of gelatin. Quince stabilizer was found to dissolve readily in ice cream mix at a very wide range of temperatures. The action of quince upon mix viscosity was immediate, in contrast to gelatin which causes an increase with time. Mixes stabilized with 0.032% quince developed much less viscosity than similar mixes stabilized with gelatin.

Quince stabilized ice cream did not melt as uniformly as did those stabilized with gelatin.

At the present time quince seed must be imported and its high cost makes prohibitive its use as an ice cream stabilizer. J.H.E.

MILK

210. Safeguarding the Public Milk Supply in War Time. C. J. BABCOCK, Major, Sanitary Corps, Army Service Forces. Milk Dealer, *33*, No. 6: 31–32, 72–74. March, 1944.

The problems involved are the same as in peace time but complicated in that loss of enforcement personnel, population shifts, establishment of army camps, lack of processing machinery and availability of milk have been retarding factors in supplying adequate and safe milk for particular states, cities and towns. Importation of milk from outside sources frequently involved lowered quality standards which the Army, through the Surgeon General and the Quartermaster General charged with safety of Army milk supplies, could not condone. A system of joint control and cooperation between the Army and local control authorities has largely solved the problems involved and assured both Army and civilian personnel of a safe milk supply—made possible by importation of milk from areas of greater production and by extending local milk sheds.

Lack of sufficient control officials has made routine farm inspections difficult if not impossible. Greater emphasis must therefore be placed upon platform inspection and rigid plant control of all processing methods such as daily pasteurization and *B. coli* tests to insure safety. "The dairy industry has not been forced (in the past) by regulations to improve the quality of milk, other than that used for fluid purposes." Herein lies the big problem of obtaining greater satisfactory supplies of milk for fluid use due to general lack of quality in milk used for processing other dairy products—a postwar as well as an immediate problem if the dairy industry is to survive. The need of better butter quality is cited as an example if markets temporarily lost to butter substitutes are to be regained after the war. Local politics, lack of knowledge in control officials and slipshod inspection methods attest to lack of adequate control in many sections—sufficient in some cases to justify complete Army control to the exclusion of local control. The author stresses the need of qualified and specially trained milk control officials in every community and not merely the drafting of milk ordinances whereby a Grade A cap may be placed on a bottle of milk. Tribute is paid to the milk industry for the job it has done in producing a safe milk supply under many handicaps and in creating milk drinking habits in our soldiers. "This milk drinking habit will return with the soldier to the civilian and the per capita consumption of milk will be higher than ever before in history." C.S.T.

211. Preventing Defects in Bottled Milk and Cream. E. L. FOUTS, Dairy Technol., Agr. Expt. Sta., Gainesville, Fla. Milk Dealer, *33,* No. 5: 29–30, 62–64. Feb., 1944.

The preventing of defects in bottled milk and cream has always been of vital importance in dairy plants. Under wartime conditions, extra problems are added to dairy plant management and merit closest attention. Listed as added problems for maintenance of quality are: (1) New milk supplies from producers not before qualified to sell milk for fluid consumption. Lack of proper equipment and information on production and handling of such milk needs careful study and cooperation on part of dealers and regulatory officials. (2) The problem of inexperienced employees in the plant complicate the milk plant's problem. Special instruction and short courses for new workers are suggested as a remedy. (3) Lack of equipment and replacement machinery affect possible defects of milk and cream. Retinning and careful check and repair of all machinery is essential. (4) Less frequent delivery, while advantageous from cost of delivery standpoint, necessitates extra care in providing milk and cream free from flavor and physical defects. Flavor defects to guard against under wartime conditions are (1) oxidized flavor and rancidity, (2) bacteriological contaminations through lack of proper care from cow to container, (3) coliform organisms and (4) poor keeping quality. Eternal vigilance in all processing and handling steps will do much to control and reduce such defects in bottled milk. The defects to avoid in bottled cream of 19% are (1) cream plug, (2) oiling off, (3) feathering and (4) lack of viscosity. To avoid, use fresh cream, handle carefully, heat and cool rapidly, age 24 hours at 35 to 40°, and bottle and sell promptly. C.S.T.

212. **Postwar Milk Distribution Possibilities.** E. J. MATHER, Exec. Vice-Pres., National Dairy Products Corp. Milk Dealer, *33,* No. 35: 33–34. Feb., 1944.

"More people are drinking more milk" than ever before in the United States. This increase has been brought about by the boost given milk consumption by the Army, defense plants, lend-lease and nutrition specialists. Tomorrow's problem is to preserve our present per capita intake of milk. The author stresses need of emphasizing the distinctive flavor of milk as inherent in milk from healthy cows fed correctly and the milk kept free from contamination from the cow to the table. Proper equipment for so producing and handling milk on the farm should therefore be stressed in the dairy equipment supply field. The responsibility of retaining wartime consumptive demands in postwar period is up to the farmer, the supply man and the processor of milk and milk products with economies of present production, procurement, processing and distribution continued and further reductions in manufacturing costs, labor and in equipment to the greatest extent. Then will volume be maintained at lower costs but still at a profit.
C.S.T.

213. **Influence of Cooling Methods on Bacteria in Milk.** T. G. ANDERSON AND JOHN E. NICHOLAS, Penn. State Col. School of Agr. Bul. 454. Sept., 1943.

The milk used in this study was that produced by the college herd. Initial temperature of the milk at the time it was inserted in the cooler varied from 80.5° to 96° F. with an average of 90° F. Temperature measurements of the milk and cooling water were made with thermocouples. When cooling milk with well or spring water it is necessary that the water temperature not rise higher than 50° F. to produce satisfactory results. Running water should have a temperature of 48° or less. When using ice at least five pounds per gallon of milk are necessary. Ninety per cent of the bacteria in milk are concentrated in the cream layer, two hours after milking. The bacteria remain evenly distributed throughout in the case of homogenized milk. P.H.T.

214. Milk and Cream Nomograph. D. S. DAVIS, Wyandotte Chemicals Corp., Wyandotte, Mich. Food Indus., *15,* No. 12: 75. Dec., 1943.

This is a graphic interpolation of data on the dependence of solids-not-fat and specific gravity on butterfat percentages in milk and cream. J.C.M.

215. Morale on the Milk Route. VIRGIL M. BENEDICT, David's Dairy, Sturgis, Mich. Milk Dealer, *33,* No. 5: 26, 66–68. Feb., 1944.

Morale is defined as "that something which urges one to give all that he or she has to achieve an objective." The author lists five points, honesty, reliability, business acumen, fairness and pride, as essential on the part of the employers of milk route salesmen if success in selling milk is to be attained. Without these qualities coupled with high morals and character the owner of a milk plant will be unable to build and sustain a high morale in the employee engaged in distributing and selling the company's products—milk and good will. C.S.T.

MISCELLANEOUS

216. Maintaining Equipment at Peak Efficiency. B. E. SAVEY, Borden's Dairy and Ice Cream Co., Columbus, Ohio. Milk Dealer, *33,* No. 6: 104–112. March, 1944.

Proper maintenance reduces repair and requires careful planning, cooperation and a "follow-up" together with rigid adherence to operating manual of each piece of equipment as furnished by the manufacturer and a control system and record of all lubrication, repairs needed or effected, breakdowns or changes made. The factors to consider and stress in maintaining peak efficiency in a dairy plant are (1) proper and careful cleaning of all equipment by all employees; (2) care and repair of pasteurizers; (3) check gauge, packing, oil, valves and drive on homogenizers; (4) check float control, temperatures and scale accumulation on all coolers; (5) pumps should be regularly inspected for packing, gaskets, couplings, covers, pipe connections and motors; (6) clean, oil, check load, keep covered, rewind and overhaul all motors regularly; (7) check wear, grease, gears and replacement parts on all gear boxes; and (8) thoroughly check and inspect all ammonia compressors and condensers in order to avoid a slow-up or breakdown in refrigeration system. Eternal vigilance with all equipment is the keynote of continued operation under wartime conditions in every dairy products plant. C.S.T.

217. Aerodynamic Fly Control. GERALD E. ZICH, N. J. Dept. of Agr., Trenton, N. J. Milk Dealer, *33,* No. 6: 29. March, 1944.

A method whereby a current of air, generated by a quarter-horsepower motor blower placed over each doorway, chute or opening is directed downward to curtain the entire opening is described. The air is trained by the angle of a metal flange and then deflected outward at the bottom, blowing the fly or insect back into space instead of into the bottling plant. Diagrams illustrating installation and operation accompany article on this fly control measure said to be effective in eliminating flies in dairies and in milk plants. C.S.T.

218. Postwar Planning in the Dairy Industry. MERRILL O. MAUGHAN. Milk Dealer, *33,* No. 6: 76–82. March, 1944.

Changing conditions brought about by the war will force the dairy industry to face many new problems. The things to expect as an aftermath of war are listed as follows: 1. Great excesses of goods in all fields with resultant increased competition between industries and between individual concerns. 2. Decreased earnings and reduced working hours, cushioned however by accumulative shortages in many consumer goods. 3. Continued government control of many industries to better effectuate diversion from war to peace status. 4. High consumption for dairy products due to increased emphasis upon nutritional value of all dairy products and upon increased demand of soldiers returning to civilian life "sold" on the value of dairy products. 5. Continued high taxes will prevail. 6. Strong labor unions will continue as a factor in all industries.

"Postwar planning should become postwar preparedness." Suggestions for the dairy industry to adopt now are as follows: 1. Plan for extensive promotion of all dairy products—a National Dairy Council unit in every state and principal market. Plan for both domestic and foreign markets. 2. Plan for extensive research to develop new uses, marketing methods and advertising. 3. Plan for more group action by forming and supporting strong trade associations. 4. Retain good features of war-imposed restrictions and eliminate bad of pre-war practices. 5. Stress quality for all dairy products. 6. Provide for utilization of surplus fluid milk. 7. Return to the realm of economic reality. 8. Plan for greater efficiencies in procurement, labor, processing and sales. 9. Improve our relations with the public. 10. Think in terms of the welfare of the entire industry. "Lets keep faith with each other and in our democratic form of Government." C.S.T.

219. Some Suggestions for Keeping Those Trucks Rolling. J. N. BAUMAN, White Motor Co. Ice Cream Rev., *27,* No. 6: 21. Jan., 1944.

Three fundamental things must be carried out if trucks are to be kept in efficient operation. These are (1) adequate and correct maintenance, (2) availability of parts when needed, and (3) proper care of truck equipment by the driver. J.H.E.

220. Manual of Dairy Detergents and Cleaning Practices. M. E. PARKER, Beatrice Creamery Co., Chicago, Ill. Food Indus., *15,* No. 7: 78. July, 1943.

The attributes and shortcomings of the various types of dairy washing compounds are cited and directions for cleaning cream cans, separators and farm utensils are given.

Effective cleaning of cream transport cans, separator parts and farm utensils is not attained by the mere use of washing compounds and chemical sterilizers. The purpose of any dairy cleaner is to prepare dirt, milk solids and grease for its subsequent detachment by brushing and its final elimination by rinsing.

As with many things about which dairymen have little exact knowledge, many dairy washing compounds sometimes are invested with magical powers. Their function is to remove dirt and grease. This is all any good cleaner can do. Differences in price may be based on the different qualities and combinations of the chemicals used, and other materials added to combat hardness in water or to give the cleaner some special character.

Selecting the right cleaner would be a simple matter if soft water were available everywhere. The degree of hardness in water varies in different parts of the country, even from town to town in some sections.

The various kinds of washing compounds available for dairy cleaning purposes may be classified generally as follows:

1. The alkalies and alkaline salts, such as caustic soda, sodium metasilicate, trisodium phosphate, sodium carbonate and bicarbonate of soda, or various mixtures of such chemicals.

2. The acid materials used for waterstone and milkstone removal, such as inhibited muriatic acid (hydrochloric acid), phosphoric acid, tartaric acid, as well as the new acid cleaners for general cleaning developed within recent years.

3. Natural materials such as wetting agents which rely on neither acidic or alkaline properties in their use.

4. The water-conditioning chemicals commonly referred to as the polyphosphates, which in general have no marked detergent characteristics but do have special properties in the compounding or application of effective cleaner mixtures, nevertheless.

5. Miscellaneous materials such as abrasives, metal cloth, and so forth, which are used as mechanical aids with or without cleaning compounds.

J.C.M.

221. What's Ahead for Private Motor Trucks? JOSEPH B. EASTMAN, Dir., Office of Defense Transportation. Milk Dealer, *33,* No. 5: 31, 88–89. Feb., 1944.

Three factors stand out in private motor truck transportation. (1) Dependency of domestic economy and war effort on motor truck transportation. (2) The extent of loss of rubber for truck tires. (3) Competition of private trucks for wartime equipment, repairs and tires. In 1941, 700,000 motor truck units were sold as compared with 100,000 units in 1942 and 1943 but illustrates the complicated problems involved in continuing to operate, maintain and conserve motor truck transportation in the face of increased demands. Office of Defense Transportation's certificate of war necessity records shows a 20% mileage saving in truck operation despite increased demands. Private trucks have accomplished great savings by elimination of extra delivery, by consolidation of routes, greater loads, etc., and have effected in individual cases as much as 40% savings. These savings have not been made by all private trucks and a plan is made for 100% cooperation if private motor trucks are to continue to carry their fair share of wartime hauling. C.S.T.

222. Mechanical Treatment Destroys Insects in Foods. E. S. STATELER, Food Indus., New York City. Food Indus., *15,* No. 7: 82. July, 1943.

Under peacetime conditions, the estimated annual loss of $600,000,000 is an exorbitant toll to pay in food and grain supplies because of insect infestation. Under present conditions, that loss, which may become even greater because of handling, storage and shipping difficulties, is more serious than the mere monetary value involved.

The article contains procedures and precautions which are of value to anyone interested in processing food materials. J.C.M.

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Right—Mess Hall scene, Army Air Forces Training Command, Chanute Field, Rantoul, Illinois.

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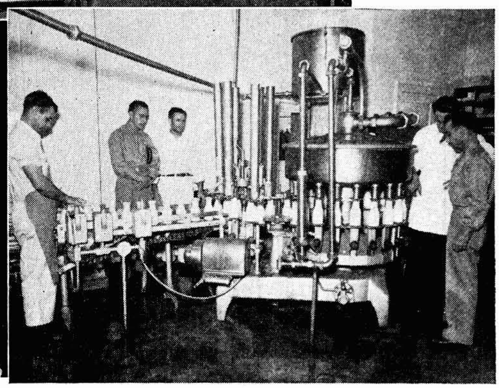
Below—Army Air Force Inspectors and Rantoul Sanitary Milk Co. officials watch operation of the Cherry-Burrell GRA-VAC Filler. Photos courtesy Army Air Forces Training Command.



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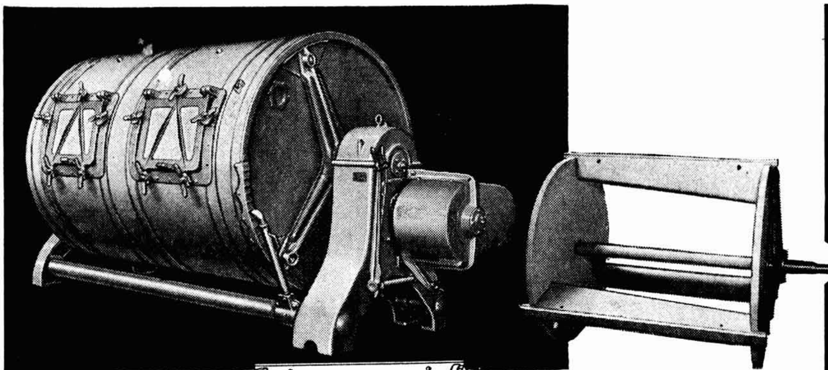

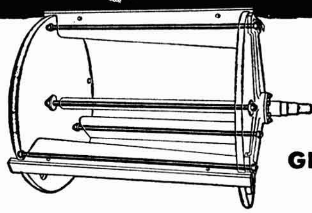

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