

THE EFFECT OF EARLY LACTATION SKIMMILK
IN MAKING COTTAGE CHEESE AND CULTURES

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COTTAGE CHEESE AND CULTURES

By

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AN ABSTRACT

Submitted to the College of Agriculture
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Lawrence J. Harmon

ABSTRACT

Cottage cheese was made from blends of skimmilk containing from 0 to 25 per cent colostrum and cultured buttermilk was made from blends of skimmilk containing from 1 to 50 per cent colostrum. The milks used in making cheese were analyzed for protein content, starter activity, curd tension at the time of cutting the curd, yield and characteristics of the finished curd. The samples propagated as cultures were analyzed for starter activity and the curd tension of the coagulated milks.

The starter organisms produced sufficient acid to coagulate all of the vats of milk. In some instances acid production was delayed, but not completely inhibited.

The amounts of total, non-casein, and globulin proteins were usually slightly higher in the blended milks. The curd tension was normal at the time of cutting the curd in most of the vats of milk containing colostrum skimmilk. In the blended milks there appeared to be an inverse relationship between globulin protein content and curd tension.

There was no significant difference in yield between the vats of normal skimmilk, and normal skimmilk blended with various percentages of colostrum skimmilk.

The body and texture characteristics of the finished cheese were not materially affected when colostrum skimmilk was included in normal skimmilk. The particles of curd

formed from coagulated milk with a tension of less than 50 grams were not uniform in size and shape, and the use of "bloody" colostrum resulted in an undesirable grey curd.

When cultures were propagated the starter organisms usually produced less acid in the normal skim milk, than in the blends of normal and colostrum skim milk, with the acid increasing as the per cent of colostrum increased. Also the curd tension was usually higher in the coagulated milks containing colostrum. The greater starter activity and higher curd tension values were attributed to the high total solids content of colostrum.

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INTRODUCTION

Cottage cheese and cultured buttermilk are highly nutritious foods which are increasing in popularity. Between 1953 and 1956 the annual per capita consumption of cottage cheese in the United States increased from 3.1 to 4.5 pounds.¹ Also, in some areas of the United States, particularly the South, cultured buttermilk accounts for 20 to 45 per cent of the bottled fluid milk. Uniform flavor and composition must be maintained if these products are to be successful in the market. Milk composition is one of several variables which may affect the desirability of these products.

The stage of lactation is one factor which affects the composition of milk. Reports in the literature indicate that colostrum and early lactation milk should be avoided in milk supplies used for the manufacture of cultured products. These reports however, do not contain specific data indicating in what manner the cheese is affected or how much early lactation milk may be tolerated. Several questions have remained unanswered. Are the starter organisms inhibited? Does the milk coagulate satisfactorily? How is the yield affected? If curd is formed how does it handle during the cooking operation and how does the finished curd compare with normal curd?

¹ Southern Dairy Products Journal, 62 (1): 106. 1957.

This research was conducted to determine how cottage cheese and starters are affected by the use of milk from the early stages of lactation.

REVIEW OF LITERATURE

Cottage Cheese

Literature reports (3, 11, 33, 34) indicate that colostrum should be excluded from milk supplies used for the manufacture of cottage cheese and cultured buttermilk. However, the reports fail to indicate the specific effects of colostrum on these products.

Hales (11) reported that sometimes trouble was encountered with milk from cows early or late in their lactation periods. According to Tuckey (34) colostrum milk and mastitis milk contains inhibitory substances which tend to retard the growth of starter cultures. Davis and McClemont (8) also report that slowness of starters may result from mastitis infected milk. Colostrum also contains protective bodies for the young suckling animals and a high percentage of non-casein proteins, which allegedly do not produce satisfactory curd for cheese making (3). Particularly in areas where milk production is seasonal, many cottage cheese manufactures have experienced instances when skim milk appeared to coagulate normally but the curd tended to dissolve and became soft and mushy during the cooking process. Tretsen (33) attributes this improper coagulation to the fact that milk produced at parturition and during early lactation, especially in the spring, differs in composition from milk produced after prolonged lactation.

Tretsven (33) prepared cottage cheese using colostrum milk and skimmilk containing 5 per cent by weight of fresh egg whites; both of these preparations contained large amounts of heat coagulable protein. He was unable to make cheese from either properly pasteurized colostrum or from properly pasteurized skimmilk containing the added egg whites. When the colostrum was not pasteurized, the curd formed and expelled whey readily; however, the cooked curd from this colostrum was not a typical cheese curd. In contrast, the unpasteurized mixture of skimmilk and egg whites gave a typical curd which expelled whey readily.

Hales (11) reported that the characteristics desired in cottage cheese curd are: (a) thorough and uniform coagulation of the casein, (b) desired firmness of the curd for convenient and efficient handling without excessive matting or shattering, and (c) a curd which will exude whey readily. Heinemann (14) reported that at the time of cutting, a curd strength of 50, 100, and 160 grams would be considered a soft, normal, and firm coagulum, respectively, in normal milk.

Cultured Buttermilk

Little information is available relating to the effect of early lactation milk on the manufacture of cultured buttermilk. Prouty (22) describes cultured buttermilk as a product in which a sequence of changes take place, dependent

upon desirable fermentations accomplished by cultures of streptococci which produce lactic acid, and leuconostocs which produce chemical components associated with desirable flavor and aroma. Angevine (2) emphasized the importance of milk composition and quality for the production of a uniform buttermilk.

Composition of Colostrum

Roadhouse and Henderson (26) described colostrum as being reddish yellow, with a strong odor and bitter flavor. They found it contained more globulin, albumin, casein, and ash, and less lactose than normal milk. Newlander (21) noted that the pH of colostrum ranged from 6.25 on the first day to 6.46 on the third day, while the average pH of fresh milk was 6.6 to 6.7.

Sato et al. (28) found colostrum of the same and different cows to be extremely variable in chemical composition. They found that the specific gravity and total ash were fairly constant, but wide fluctuation occurred in the hydrogen ion concentration, color, and intensity and firmness of coagulation. Also the percentages of lactose, fat, total protein, and relative proportions of each individual protein also varied considerably.

Large amounts of antibody protein were present in colostrum (10, 16, 20, 23, 26). Riddell et al. (25) analyzed the milk from seven cows and found the first

milking after parturition averaged 2.92 per cent albumin and 7.90 per cent globulin. The milk obtained on the 28th day after parturition averaged 0.29 per cent albumin and 0.27 per cent globulin. Neurath and Bailey (20) noted that thirty days before discontinuing milking at the end of the lactation period, the globulin and albumin components began to increase progressively. At parturition the colostrum globulin exceeded all the other proteins. The globulin content is usually considerably less in the second milking than the first milking. Smith (32) observed that the globulin content of representative samples obtained from the second milking from three cows contained 12, 30, and 55 per cent of the total protein contained in the first milkings.

According to Ragsdale and Brody (23), the globulin in colostrum is identical to the globulin in blood serum. Neurath and Bailey (20) reported that colostrum globulin was essentially the same as the immune globulin of normal milk.

The investigations of Garrett and Overman (10) showed that colostrum was high in calcium, magnesium, sodium, phosphorous and chlorine, especially at parturition and during the early hours of lactation, but the level of these substances declined rapidly toward a fairly constant level as the milk became normal. Potassium was comparatively low at parturition but gradually increased to a uniform level

as the milk became normal. Other workers (28, 29) found that the first milk after parturition contained a much larger amount of manganese than normal milk and the zinc content was quite high immediately after parturition, but declined to a relatively constant value after about ten days.

Laskowski and Laskowski (17) reported that bovine and human colostrum contained significant amounts of trypsin inhibitor. Both Neurath and Bailey (20) and Laskowski and Laskowski (17) suggested that the function of the trypsin inhibitor in colostrum was to prevent the hydrolysis of the immune proteins in the alimentary tract.

Curd Tension

Colostrum usually has a higher curd tension than normal milk (7, 15, 25). Berry (7) found that initial colostrum formed a very hard curd, followed by a slight decrease in curd tension as the milk approached normality. Thereafter the curd tension was usually fairly uniform throughout the lactation period. Riddell et al. (25) observed that in a majority of instances maximum curd tensions were observed on the third to the fifth days after parturition, followed by irregular decreases until uniformity was attained. However, in a few instances, the highest values occurred in the initial colostrum. This irregular behavior in curd tension following parturition was

attributed to major variations in the serum solids portion of the secretion, particularly the protein and ash constituents.

Weisberg et al. (35) associated high and low concentration of casein with hard and soft curd milks, respectively. According to Riddell et al. (25) there was a high correlation between the casein content and the curd tension in normal milk, but the curd tension values did not correlate closely with the casein in the initial three or four milkings. After the fourth milking the correlation improved progressively and became stabilized at the end of the first month of the lactation period. Therefore, they assumed that in the early milkings, the high globulin and albumin content of the milk undoubtedly were modifying influences on curd tension, but since the concentration of globulin and albumin decreased much more rapidly than the casein, the latter soon became the dominant factor. Data reported by Weisberg et al. (35) showed that the ratio of casein to whey proteins could be decreased from 4.5 to 1.5 and still maintain the same curd strength.

In normal milk Berry (7) observed little variation in the curd tension between milkings of the same day or of consecutive days. He found no seasonal variation in the curd tension of milk.

Starter Activity

Rice (24) reported on the effect of colostrum on the lactic acid fermentation. He pointed out that colostrum was known to inhibit certain microorganisms such as typical udder pathogens and coliforms. This inhibition was attributed to agglutination but there appeared to be no evidence in the literature that colostrum possessed agglutinins for true lactic acid streptococci. The above worker studied the rate of acid development by lactic streptococci in colostrum and in normal milk containing varying proportions of colostrum. He concluded that 10 per cent or more colostrum in normal milk will stimulate acid production and attributed this to the high buffer value of colostrum.

Sato et al. (28) reported that with the normal parturition, colostrum always contains agglutinins. According to Houdiniere (16) colostrum is rich in opsonins, and contains agglutinins, precipitins and lytic antibodies for some types of organisms. However, according to Rice (24) the lactic acid streptococci are not affected by the above inhibitory agents.

Lactenins

Auclair (4) reported that the natural inhibition of microorganisms in milk is attributed to lactenin I and lactenin II. Colostrum is high in lactenin I, and lactenin II predominates at mid-lactation (4). Auclair and Hirsch

(5) observed that the inhibitory activity of lactenin I was much greater than lactenin II. They heated milk to 70° C. for 20 minutes and observed that nearly all of the inhibitory activity of lactenin II was lost. When they added an equal part of raw colostrum to heated milk, the activity was restored. They also added one part of raw colostrum to 100 parts of heat-treated milk and found an inhibition comparable to that of raw milk.

Wilson (36) reported that lactenins apparently required oxygen or a high oxidation-reduction potential before they were inhibitory. He noted that when milk was inoculated with a streptococcus and incubated in an anaerobic jar or when a chemical reducing agent such as cysteine was added, the organisms grew well. Addition of excess thiamine rendered the lactenin inactive.

EXPERIMENTAL PROCEDURES

This project was conducted to determine how cottage cheese and starters are affected when made from milk containing portions of colostrum or milk produced during the early stages of lactation. Throughout this discussion the early lactation milk will be referred to as "colostrum" although some of it was obtained as late as 10 days after calving.

The colostrum used for making cheese and starters was secured from individual cows in the Michigan State University dairy herd. The colostrum was obtained on approximately the fourth, seventh, and tenth days after parturition. Collection was started on the fourth day, primarily because colostrum appears almost normal at that time and some producers are prone to include this milk in their supply.

The colostrum skim milk was blended with normal skim milk obtained from the Michigan State University Dairy Plant. These blended mixtures were made into cottage cheese by the short-set method. The primary motive was to determine if a satisfactory cottage cheese could be made from normal skim milk that contained colostrum skim milk. Analyses were performed to determine starter activity, curd tension at the time of cutting, yield, and the appearance of the finished curd. The percentages of total, non-casein, and globulin

protein contained in the blended milks were determined. Flavor was not evaluated; however, admittedly it is important in commercial practice.

Starters were made from blends of normal skimmilk and colostrum skimmilk. Curd tension and developed acidity tests were made on the coagulated milks.

Cottage Cheese

The colostrum was separated at 90° F. The skimmilk was pasteurized at 143° F. for 30 minutes in a two gallon Safgard Home Milk Pasteurizer¹ or in a steam heated water bath. The pasteurized skimmilk was cooled by passing over a plate cooler or by placing in a 32° F. water bath. The cooled skimmilk was held until the following day.

Normal skimmilk pasteurized at 162° F. for 15 seconds or 143° F. for 30 minutes was obtained from the Michigan State University Dairy Plant in sufficient quantity to make four vats of cheese. The use of the same milk for all four vats of cheese in each trial permitted a direct comparison of results. The milk was stored at 32° to 35° F. until it was used, usually a period of seven to ten days. No deterioration appeared in the skimmilk during storage.

Each trial included a control vat of cheese made from normal skimmilk, and three vats of cheese made from normal skimmilk plus colostrum skimmilk produced on the fourth,

¹ Guardit Manufacturing Company, 615 North Aberdeen Street, Chicago, Illinois.

seventh, and tenth days after parturition, respectively. Specific percentages of colostrum skim milk were included in each trial, the amounts being 3, 5, 10, and 25 per cent by weight. Duplicate trials were performed using each of these percentages of colostrum skim milk. In the first and second trials made with milk containing three per cent colostrum, an additional vat of cheese was made from milk containing colostrum produced on the sixth and second days after parturition, respectively.

Forty to fifty gallons of milk were made into cottage cheese in a 100 gallon capacity Cherry-Burrell cheese vat. The blended milk was thoroughly mixed and a sample obtained for protein analysis. After addition of the starter, a sample of the inoculated milk was obtained for total solids analysis.

The inoculated milk was stirred approximately every 15 minutes until the acidity reached 0.25 to 0.26 per cent. At this point, rennet was added at the rate of 1 ml. per 1000 pounds of milk, except for one series of vats of cheese made without rennet. Two eight-ounce sample jars containing 180 ml. of milk were suspended in the vat and incubated therein until the curd in the vat was ready to cut, at which time the jars were removed and the curd tension was measured with a Submarine Signal Company curd-o-meter. The curd tension of the milk in the jars corresponded to the curd tension of the coagulum in the vat. The highest

accurate reading obtainable on the meter was 150 grams; therefore, several vats of curd are reported as having a curd tension of 150 grams even though the reading may have been higher.

A sample of the cheese curd was centrifuged in a cream test bottle to obtain whey for the acidity test. The curd was cut when the whey acidity was 0.50 to 0.54 per cent lactic acid equivalent, except the vats set without rennet, which were cut at 0.58 to 0.63 per cent acidity.

The curd was cut with one-half inch cheese knives and allowed to stand for 15 minutes before cooking and agitation were started. An additional 65 to 75 minutes were used for cooking the curd to 120° to 125° F. with the final acidity increasing to 0.56 to 0.58 per cent. No water was added to the curd before or during cooking. Precautions were observed to minimize the amount of solids lost.

After adding the first and second wash waters the temperature of the curd was 80° to 85° F. and 50° to 55° F., respectively. The wash waters were drained into ten gallon cans and retained for subsequent analysis.

The washed curd was allowed to drain for at least one hour and then thoroughly mixed to obtain a representative sample for total solids determinations.

Analyses were made on the whey and wash waters to determine the total solids lost in each. To facilitate accurate sampling, the whey and wash waters were homogenized

separately at 2000 pounds pressure in a Cherry-Burrell or a Manton Gaulin homogenizer. Homogenization caused the small curd particles to remain in suspension for several hours.

After homogenization the whey and wash waters were weighed and dumped separately into the cheese vat, thoroughly agitated and representative samples were obtained.

Starters

Blends of skimmilk were made by adding quantities varying from 1 to 50 per cent by weight of colostrum skimmilk to normal skimmilk. The blended milks were used to prepare starter cultures. Samples of colostrum were obtained intermittently throughout the first ten days after parturition. The normal skimmilk was obtained in sufficient volume to permit use of the same milk throughout each trial. Two hundred ml. quantities of milk were made up from normal skimmilk plus **varying** percentages of colostrum skimmilk and placed in eight ounce sample jars.

The blended milks were steamed at 212° F. for 30 minutes in an autoclave. The samples were removed from the autoclave, allowed to cool at room temperature to 160° F., and then cooled in flowing water to 72° F.

One per cent starter was added, the acidity was determined, and the inoculated cultures were then incubated at 72° F. for 15 hours.

At the conclusion of the incubation, the curd tension

was measured with a Submarine Signal Company curd tension meter. The curd was then broken, thoroughly mixed, and the acidity was determined by titration. A comparison was made of the difference between the initial and the final acidity of each mixture which contained colostrum skimmilk, and the corresponding control which contained no colostrum.

ANALYTICAL PROCEDURES

Total Solids Analyses

The Mojonnier method (19) was used to determine the total solids contained in the inoculated cheese milk, whey, and wash waters. The total solids content of the cheese curd was determined by the procedure outlined by Harmon et al. (13). The amounts of total solids retained in the curd and lost in the whey and wash waters were calculated.

Protein Analyses

Total nitrogen, non-casein nitrogen and globulin nitrogen were determined by the procedure outlined by Shahani and Sommer (31). The per cent protein in each fraction was obtained by multiplying the per cent nitrogen by 6.38. Globulin nitrogen refers to the fraction that contains the euglobulin and pseudoglobulin nitrogen. Duplicate analyses were made on each of the protein fractions.

Blank determinations involving digestion, distillation, and titration procedures were made on 9.5 ml. of distilled

water plus the usual amount of reagents used in measuring the total, and non-casein nitrogen, and on a sheet of filter paper plus the usual amount of reagents used in determining globulin nitrogen.

The per cent nitrogen was calculated by the following formula:

$$\frac{(\text{ml. acid} - \text{blank})(\text{N acid})(0.014 \text{ meq. Nitrogen})}{\text{wt. of sample in grams}} \times 100 =$$

$$\% \text{ Nitrogen} \times 6.38 = \% \text{ protein.}$$

RESULTS

Cottage Cheese

Normal Skimmilk Containing Three Per Cent Colostrum.

The colostrum skimmilk used in making the curd in the series of vats in the first trial was secured from a Holstein cow in the third lactation period.

In the vat of normal skimmilk, 5.75 hours elapsed between setting the milk and cutting the curd (Table I). In the vats of normal skimmilk plus colostrum skimmilk produced on the fourth, sixth, seventh, and tenth days after parturition, 6.92, 6.17, 7.75, and 6.75 hours, respectively, elapsed between setting and cutting. The curd tension was 150 grams or more in each of the vats of curd, except the one containing colostrum produced on the seventh day after parturition, which had a curd tension of only 121 grams. In the vat of cheese made from normal skimmilk, 37.83 per cent of the milk solids were retained in the curd. When colostrum skimmilk produced on the fourth, sixth, seventh, and tenth days after parturition was blended with normal skimmilk, 35.97, 36.66, 34.30, and 36.70 per cent, respectively, of the milk solids were retained in the curd. There were no apparent differences in the body, texture, or appearance between the control and the experimental cheese.

A Holstein cow in the second lactation period produced

TABLE I

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING THREE PER CENT COLOSTRUM SKIMMILK SOURD
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A HOLSTEIN COW IN THE THIRD
LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing three per cent colostrum skimmilk			
		Days after parturition			
		4	6	7	10
Setting to cutting (hrs.)	5.75	6.92	6.17	7.75	6.75
Acidity at cutting (%)	.52	.58	.52	.53	.52
Curd tension at cutting (g.)	150	150	150	121	150
Wt. of milk plus starter (lbs.)	446	346	371	384	373
Total solids in inoculated milk (%)	9.20	9.28	9.11	9.26	9.24
Total milk solids (lbs.)	41.06	32.11	33.80	35.55	34.48
Total milk solids recovered in cheese (%)	37.83	35.97	36.66	34.30	36.70
Total milk solids lost in whey (%)	42.36	42.42	36.67	41.76	37.63
Total milk solids lost in wash-water (%)	19.75	18.57	26.06	17.78	23.35
Total solids accounted for (%)	99.94	96.96	99.39	93.84	97.68

the colostrum skimmilk used in the series of vats of curd in the second trial (Table II). The starter activity, yield, body and texture were similar in the vats of curd made from normal skimmilk and from normal skimmilk containing 3 per cent colostrum produced on the second and fourth days after calving. However, the vats of milk containing colostrum produced on the seventh and tenth days after parturition required 9.67 and 8.50 hours, respectively, to attain sufficient acidity and coagulation to warrant cutting the curd. The curd tension of the coagulated milk in these vats was 115 and 123 grams, respectively, as compared to 150 grams for the curd made from regular skimmilk. In the vat of cheese made from normal skimmilk, 37.55 per cent of the milk solids were retained in the curd. In the vats of cheese made from normal skimmilk plus separated colostrum secured on the second, fourth, seventh, and tenth days after calving, 38.08, 37.29, 36.70, and 36.91 per cent, respectively, of the milk solids were retained in the curd. The body was soft in the finished curd made from blended skimmilk containing colostrum produced on the seventh and tenth days after parturition. An objectionable grey color prevailed in the finished vats of cheese made from normal skimmilk plus separated colostrum secured on the second and fourth days after parturition.

Normal Skimmilk Containing Five Per Cent Colostrum.

The colostrum skimmilk used in the series of vats of curd

TABLE II

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING THREE PER CENT COLOSTRUM SKIMMILK SECURED
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A HOLSTEIN COW IN THE SECOND
LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing three per cent colostrum skimmilk			
		Days after parturition			
		2	4	7	10
Setting to cutting (hrs.)	6.08	6.17	6.50	9.67	8.50
Acidity at cutting (%)	.53	.52	.52	.53	.52
Curd tension at cutting (g.)	150	150	150	115	123
Wt. of milk plus starter (lbs.)	452	466	466	466	466
Total solids in inoculated milk (%)	9.19	9.20	9.18	9.20	9.17
Total milk solids (lbs.)	41.50	42.89	42.79	42.88	42.74
Total milk solids recovered in cheese (%)	37.55	38.08	37.29	36.70	36.91
Total milk solids lost in whey (%)	41.50	41.82	43.29	43.04	40.98
Total milk solids lost in wash-water (%)	16.44	18.99	18.89	17.40	17.39
Total solids accounted for (%)	95.49	98.89	99.47	97.14	95.28

in the first trial was secured from a Holstein cow in the fourth lactation period.

The time between setting the milk and cutting the curd in the vat of normal skimmilk was 5.42 hours (Table III). The blends of normal and colostrum skimmilk produced on the fourth, seventh, and tenth days after calving required 5.42, 5.92, and 6.00 hours, respectively, between setting the milk and cutting the curd. The curd tension of the control vat of coagulated skimmilk was 150 grams. The curd tension of the vats of curd made from normal skimmilk and colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition was 67, 134, and 133 grams, respectively. The cheese made from normal skimmilk retained 39.34 per cent of the milk solids in the curd. When colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition was blended with normal skimmilk, 39.21, 36.35, and 36.22 per cent, respectively, of the milk solids were retained in the curd. The control cheese and the cheese made from normal skimmilk containing colostrum were similar in body, texture, and appearance.

The colostrum used in the series of vats of curd in the next trial was secured from a Holstein cow in the third lactation period. In this series of vats the cheese was made without rennet.

The vat of normal skimmilk (control) required 7.50 hours between setting the milk and cutting the curd (Table

TABLE III

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING FIVE PER CENT COLOSTRUM SKIMMILK SECURED
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A HOLSTEIN COW IN THE FOURTH
LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing five per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	5.42	5.42	5.92	6.00
Acidity at cutting (%)	.53	.53	.52	.53
Curd tension at cutting (g.)	150	67	134	133
Wt. of milk plus starter (lbs.)	451	474	475	474
Total solids in inoculated milk (%)	8.70	8.73	8.72	8.81
Total milk solids (lbs.)	39.28	41.40	41.43	41.78
Total milk solids recovered in cheese (%)	39.34	39.21	36.35	36.22
Total milk solids lost in whey (%)	44.23	44.34	47.67	37.01
Total milk solids lost in wash-water (%)	13.97	14.59	13.67	23.61
Total solids accounted for (%)	97.54	98.14	97.69	96.84

IV). The blends of milk containing regular skimmilk plus separated colostrum produced on the fourth and tenth days after calving required 7.75 and 7.25 hours, respectively, between setting the milk and cutting the curd. The colostrum produced on the seventh day after parturition was not used in making cheese, since it was infected with mastitis organisms. The tension of the curd made from normal skimmilk was 10 grams. The tension of the vats of curd made from normal skimmilk and colostrum skimmilk produced on the fourth and tenth days after parturition was 11 and 8 grams, respectively. The cheese made from the control skimmilk, contained 37.66 per cent of the original milk solids. The per cent of the milk solids retained in the curd made from normal skimmilk containing colostrum skimmilk produced on the fourth and tenth days after parturition was 38.77 and 37.07 per cent, respectively. There was no apparent difference in the body, texture, or appearance between the cheese made from normal skimmilk and the cheese made from the blended milks.

Normal Skimmilk Containing Ten Per Cent Colostrum. A Brown Swiss cow in the second lactation period produced the colostrum used in the series of vats of curd in the first trial.

The coagulating time was 6.42 hours in the vat of normal skimmilk (Table V). The control skimmilk plus colostrum skimmilk secured on the fourth, seventh, and tenth days after calving required 6.58, 7.00, and 6.08 hours,

TABLE IV

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING FIVE PER CENT COLOSTRUM SKIMMILK SECURED
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A HOLSTEIN COW IN THE THIRD
LACTATION PERIOD*

	Control (normal skimmilk)	Normal skimmilk containing five per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	7.50	7.75	**	7.25
Acidity at cutting (%)	.58	.63		.59
Curd tension at cutting (g.)	10	11		8
Wt. of milk plus starter (lbs.)	457	382		471
Total solids in inoculated milk (%)	9.07	9.22		8.94
Total milk solids (lbs.)	41.44	35.18		42.08
Total milk solids recovered in cheese (%)	37.66	38.77		37.07
Total milk solids lost in whey (%)	37.55	38.01		36.68
Total milk solids lost in wash-water (%)	22.97	23.13		20.44
Total solids accounted for (%)	98.18	99.91		96.19

* Coagulated without rennet.

** Mastitis milk.

TABLE V

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING TEN PER CENT COLOSTRUM SKIMMILK SECURED
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A BROWN SWISS COW IN THE
SECOND LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing ten per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	6.42	6.58	7.00	6.08
Acidity at cutting (%)	.52	.51	.55	.52
Curd tension at cutting (g.)	150	150	150	150
Wt. of milk plus starter (lbs.)	453	439	497	497
Total solids in inoculated milk (%)	9.00	9.09	9.24	9.00
Total milk solids (lbs.)	40.73	39.90	45.89	44.71
Total milk solids recovered in cheese (%)	37.87	37.86	39.35	39.42
Total milk solids lost in whey (%)	40.62	39.53	39.17	39.71
Total milk solids lost in wash-water (%)	16.74	18.97	21.33	18.44
Total solids accounted for (%)	95.23	96.36	99.85	97.57

respectively, between setting and cutting the curd. The per cent of milk solids retained in the curd made from normal skimmilk was 37.87. The cheese made from normal skimmilk and separated colostrum produced on the fourth, seventh, and tenth days after calving contained 37.86, 39.35, and 39.42 per cent, respectively, of the original milk solids. The body, texture, and appearance were similar in the cheese made from normal skimmilk and blended milks.

The colostrum skimmilk used in the series of vats of curd in the second trial was secured from a Holstein cow in the second lactation period.

The length of time between setting the vat of normal skimmilk and cutting the curd was 5.67 hours (Table VI). The blends of normal and colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition required 5.50, 6.83, and 5.25 hours, respectively, between setting and cutting. The curd tension was 150 grams or more in each of the vats of curd. In the vat of cheese made from the control skimmilk 38.91 per cent of the milk solids were retained in the curd. The per cent of the milk solids retained in the curd made from normal skimmilk plus colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition was 39.48, 39.74, and 38.56, respectively. The control cheese and the cheese made from the blended milks were similar in body, texture, and appearance.

TABLE VI

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK
CONTAINING TEN PER CENT COLOSTRUM SKIMMILK SECURED
INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER
PARTURITION FROM A HOLSTEIN COW IN THE SECOND
LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing ten per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	5.67	5.50	6.83	5.25
Acidity at cutting (%)	.54	.54	.54	.52
Curd tension at cutting (g.)	150	150	150	150
Wt. of milk plus starter (lbs.)	452	427	427	427
Total solids in inoculated milk (%)	9.46	9.57	9.61	9.51
Total milk solids (lbs.)	42.71	40.50	41.07	40.64
Total milk solids recovered in cheese (%)	38.91	39.48	39.74	38.56
Total milk solids lost in whey (%)	39.48	40.50	39.80	44.23
Total milk solids lost in wash-water (%)	19.50	19.14	18.42	18.39
Total solids accounted for (%)	97.89	99.02	97.96	101.18

Normal Skimmilk Containing Twenty-Five Per Cent

Colostrum. The colostrum used in the first trial were secured from an Ayrshire cow in the second lactation period and from a Guernsey cow in the first lactation period.

The time between setting the milk and cutting the curd in the control vat was 5.75 hours (Table VII). The blends of normal skimmilk and colostrum secured on the fourth, seventh, and tenth days after parturition required 6.75, 6.08, and 5.92 hours, respectively, between setting and cutting. The curd tension of the control vat of coagulated skimmilk was 150 grams. The curd made from normal skimmilk containing colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition had a curd tension of 32, 44, and 150 grams, respectively. The cheese made from normal skimmilk contained 38.40 per cent of the original milk solids. The amounts of milk solids retained in the curd made from normal skimmilk plus colostrum skimmilk secured on the fourth, seventh, and tenth days after parturition was 40.62, 40.88, and 36.65 per cent, respectively. Whey pockets tended to form during the early part of the cooking process in the first two vats mentioned above. An objectionable grey color prevailed in the finished vats of experimental cheese. The cheese made from normal skimmilk and the cheese made from the blended milks were similar in body, texture, and appearance.

The colostrum used in the series of vats of curd in the second trial were secured from an Ayrshire cow in the third

TABLE VII

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK CONTAINING 25 PER CENT COLOSTRUM SKIMMILK SECURED INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER PARTURITION FROM AN AYRSHIRE COW IN THE SECOND LACTATION PERIOD AND FROM A GUERNSEY COW IN THE FIRST LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing 25 per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	5.75	6.75	6.08	5.92
Acidity at cutting (%)	.52	.50	.54	.50
Curd tension at cutting (g.)	150	32	44	150
Wt. of milk plus starter (lbs.)	361	269	338	380
Total solids in inoculated milk (%)	9.07	9.20	9.28	9.16
Total milk solids (lbs.)	32.76	24.73	31.38	34.82
Total milk solids recovered in cheese (%)	38.40	40.62	40.88	36.65
Total milk solids lost in whey (%)	43.89	43.63	38.96	43.23
Total milk solids lost in wash-water (%)	16.94	18.02	20.46	18.53
Total solids accounted for (%)	99.23	102.27	100.30	98.41

lactation period, and from a Guernsey cow in the second lactation period.

The coagulation time in the vat of normal skimmilk was 5.67 hours (Table VIII). The length of time between setting the milk and cutting the curd in the vats of control skimmilk containing colostrum skimmilk secured on the fourth, seventh, and tenth days after calving was 5.42, 5.25, and 5.33 hours, respectively. The curd made from normal skimmilk had a curd tension of 150 grams. The curd tension of the vats of curd made from normal skimmilk and colostrum skimmilk produced on the fourth, seventh, and tenth days after parturition was 74, 129, and 128 grams, respectively. The per cent of the milk solids retained in the curd made from normal skimmilk was 35.45. When colostrum produced on the fourth, seventh, and tenth days after parturition was blended with normal skimmilk, 37.26, 37.86, and 35.32 per cent, respectively, of the milk solids were retained in the curd. Whey pockets tended to form during the early part of the cooking process in the cheese made from blends of normal and colostrum skimmilk. There was no apparent difference in the body, texture, or appearance, between the control and the experimental cheese.

Protein Analyses

The results in Table IX show the amounts of the protein constituents in the uninoculated milk used in making the cheese. The total protein and the non-casein protein

TABLE VIII

COTTAGE CHEESE MADE FROM NORMAL SKIMMILK AND NORMAL SKIMMILK CONTAINING 25 PER CENT COLOSTRUM SKIMMILK SECURED INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER PARTURITION FROM AN AYRSHIRE COW IN THE SECOND LACTATION PERIOD AND FROM A GUERNSEY COW IN THE SECOND LACTATION PERIOD

	Control (normal skimmilk)	Normal skimmilk containing 25 per cent colostrum skimmilk		
		Days after parturition		
		4	7	10
Setting to cutting (hrs.)	5.67	5.42	5.25	5.33
Acidity at cutting (%)	.51	.51	.51	.52
Curd tension at cutting (g.)	150	74	129	128
Wt. of milk plus starter (lbs.)	361	353	348	314
Total solids in inoculated milk (%)	9.08	9.03	9.17	9.19
Total milk solids (lbs.)	32.80	31.86	31.87	28.85
Total milk solids recovered in cheese (%)	35.45	37.26	37.86	35.32
Total milk solids lost in whey (%)	44.40	43.36	45.97	44.29
Total milk solids lost in wash-water (%)	17.52	20.52	17.00	18.66
Total solids accounted for (%)	97.37	101.14	100.83	98.27

TABLE IX

PROTEIN ANALYSES OF UNINOCULATED MILK USED IN MAKING CHEESE (NORMAL SKIMMILK CONTAINING COLOSTRUM SKIMMILK SECURED INTERMITTENTLY DURING THE FIRST TEN DAYS AFTER PARTURITION)

	Control (normal skimmilk)	Normal skimmilk containing colostrum skimmilk				
		Days after parturition				
		2	4	6	7	10
<u>Percentage of protein</u>						
Skimmilk containing 3% colostrum (Holstein)						
Total protein	3.3867	3.4367	3.5640	3.4731	3.3458	
Non-casein protein	0.7654	0.8137	0.9866	0.8187	0.9092	
Casein protein	2.6213	2.6330	2.5774	2.6544	2.4366	
Globulin protein	0.2635	0.3456	0.2772	0.2591	0.3273	
Total protein	3.4809	3.6972	3.5811	3.5113	3.4914	
Non-casein protein	0.8608	0.9308	0.9109	0.8742	0.8475	
Casein protein	2.6201	2.7664	2.6702	2.6371	2.6439	
Globulin protein	0.2908	0.2993	0.2910	0.2948	0.2906	
Skimmilk containing 5% colostrum (Holstein)						
Total protein	3.3868	3.5404		3.3194	3.3867	
Non-casein protein	0.8635	0.8691		1.1383	0.8692	
Casein protein	2.5233	2.6713		2.1809	2.5175	
Globulin protein	0.1738	0.1906		0.2186	0.2130	
Total protein	3.7456	3.6558		*	3.8802	
Non-casein protein	0.8355	0.8635			0.8298	
Casein protein	2.9101	2.7923			3.0504	
Globulin protein	0.2859	0.2859			0.2859	

* Mastitis milk.

TABLE IX (Continued)

	Control (normal skimmilk)	Normal skimmilk containing colostrum skimmilk				
		Days after parturition				
		2	4	6	7	10
<u>Percentage of protein</u>						
Skimmilk containing 10% colostrum (Brown Swiss)						
Total protein	3.9040	4.2990		3.9270	3.8170	
Non-casein protein	0.8007	0.8114		0.8116	0.8117	
Casein protein	3.1033	3.4876		3.1154	3.0053	
Globulin protein	0.2578	0.2194		0.2194	0.2523	
(Holstein)						
Total protein	3.4316	3.6386		3.5437	3.3868	
Non-casein protein	0.7850	0.9252		0.7962	0.7779	
Casein protein	2.6466	2.7134		2.7474	2.6089	
Globulin protein	0.2815	0.2523		0.2413	0.2303	
Skimmilk containing 25% colostrum (Ayrshire and Guernsey combined)						
Total protein	3.4160	3.6855		3.7070	3.6140	
Non-casein protein	0.7074	0.7349		0.8171	0.7404	
Casein protein	2.7086	2.9506		2.8899	2.8736	
Globulin protein	0.2194	0.2303		0.2413	0.2138	
(Ayrshire and Guernsey combined)						
Total protein	3.2680	3.4220		3.7510	3.5240	
Non-casein protein	0.7623	1.0694		0.7897	0.7623	
Casein protein	2.5057	2.3526		2.9613	2.7617	
Globulin protein	0.2797	0.3729		0.2852	0.2962	

usually were greater in the blended milks than in the normal milk, with the total protein and non-casein protein approaching normality as the lactation progressed. The amount of globulin protein remained fairly constant except a greater amount was noted in one trial using 3 per cent colostrum skimmilk, in one trial using 5 per cent colostrum skimmilk, and in the two trials using 25 per cent colostrum skimmilk.

Acid Development in Cultures

The initial acidity of colostrum is higher than that of normal skimmilk; therefore, the percentage of colostrum skimmilk included influenced the initial acidities of the blended milks. As the lactation progressed the acidity of the colostrum skimmilk gradually diminished until normal acidity was reached. The initial acidities of the inoculated blended milks ranged from 0.14 to 0.21 per cent. Coagulation usually occurred during the heat treatment of the blended milks containing 20 and 50 per cent colostrum skimmilk obtained from the first and third milkings after parturition.

The data indicated that the lactic acid organisms were able to produce acid at a normal rate in milks containing skimmilk produced early in the lactation period. The data in Table X show the initial, developed, and final acidities in the inoculated blends of skimmilk containing 1 to 50 per cent colostrum skimmilk secured intermittently throughout

TABLE I

INITIAL, DEVELOPED, AND FINAL ACIDITIES OF COAGULATED MILKS MADE FROM
 BLENDS OF NORMAL SKIMMILK AND NORMAL SKIMMILK CONTAINING 1 TO 50
 PER CENT OF COLOSTRUM SKIMMILK SECURED INTERMITTENTLY DURING
 THE FIRST TEN DAYS AFTER PARTURITION

Milking after calving	Breed of cow	Initial acidity					
		Per cent colostrum skim milk					
		0	1	2	5	10	20
3	Holstein	0.155	0.160	0.168	0.170	0.173	0.195
4		.155	.160	.163	.165	.170	.180
5		.155	.160	.170	.165	.180	.185
6		.150	.150	.155	.158	.160	.170
8		.150	.150	.150	.155	.165	.175
10		.143	.145	.145	.148	.150	.150
11		.143	.143	.145	.145	.150	.155
13		.140	.140	.140	.145	.150	.160
19		.140	.140	.140	.145	.150	.150
		0	1	5	10	20	50
3 & 4	Jersey	0.145	0.145	0.145	0.150	0.155	0.200
10 & 11		.140	.140	.145	.150	.160	.190
13 & 14		.150	.150	.150	.150	.165	.210
19 & 20		.160	.*	.160	.165	.175	*
1	Guernsey	0.140	0.150	0.155	0.160	**	**
3		.140	.150	.150	.150	.160	.200
5		.140	.145	.150	.155	.160	.185
7		.135	.140	.*	.150	.160	.180
13		.135	.140	.140	.140	.140	.140
19	Ayrshire	.150	.150	.150	.150	.150	.150
1		0.140	0.145	0.150	0.160	0.170	**
3		.140	.150	.155	.165	.185	**
5		.140	.140	.150	.160	.170	.205
7		.135	.140	.145	.150	.160	.210
13		.135	.140	.140	.145	.160	.180
19		.150	.150	.150	.150	.155	.160

* Laboratory accident.

** Coagulated during heat treatment.

TABLE X (Continued)

Developed acidity						Total acidity					
Per cent colostrum skim milk						Per cent colostrum skim milk					
0	1	2	5	10	20	0	1	2	5	10	20
0.620	0.620	0.627	0.625	0.652	0.665	0.775	0.780	0.795	0.795	0.825	0.860
.625	.655	.652	.650	.630	.635	.780	.815	.815	.815	.800	.815
.625	.660	.675	.655	.645	.635	.780	.820	.845	.820	.825	.820
.620	.675	.715	.687	.685	.645	.770	.825	.810	.845	.845	.815
.635	.655	.660	.660	.675	.685	.785	.805	.810	.815	.840	.860
.602	.615	.620	.602	.620	.620	.745	.760	.765	.750	.770	.770
.617	.637	.625	.615	.570	.615	.760	.780	.770	.760	.720	.770
.590	.575	.400	.025	.000	.000	.730	.725	.555	.180	.160	.160
.600	.570	.595	.585	.590	.600	.720	.710	.735	.730	.750	.760
0	1	5	10	20	50	0	1	5	10	20	50
0.650	0.650	0.660	0.660	0.665	0.720	0.795	0.795	0.805	0.810	0.820	0.920
.680	.675	.655	.650	.680	.720	.820	.815	.800	.840	.840	.910
.645	.640	.650	.655	.665	.690	.795	.790	.800	.805	.830	.900
.650	*	.650	.655	.675	*	.810	*	.810	.830	.850	*
0.580	0.590	0.630	0.630	**	**	0.720	0.740	0.785	0.790	**	**
.600	.570	.640	.645	.645	.780	.740	.720	.790	.795	.805	.980
.580	.585	.615	.630	.625	.615	.720	.730	.755	.785	.785	.900
.575	.610	*	.590	.615	.625	.710	.750	*	.740	.775	.805
.545	.565	.575	.595	.580	.650	.680	.705	.715	.735	.720	.800
.560	.555	.570	.585	.570	.635	.710	.705	.720	.735	.720	.805
0.580	0.585	0.630	0.655	0.655	**	0.720	0.730	0.780	0.815	0.825	**
.595	.600	.630	.655	.665	**	.735	.750	.785	.820	.850	**
.545	.595	.620	.640	.640	.665	.735	.735	.770	.800	.810	.860
.550	.560	.560	.575	.620	.660	.685	.700	.705	.720	.780	.870
.545	.560	.575	.590	.620	.660	.680	.735	.715	.735	.780	.840
.560	.585	.580	.585	.610	.625	.710	.735	.730	.735	.765	.785

the first ten days after parturition. The values that are reported as developed acidities in Table X show the amount of acid actually developed and are the difference between the initial acidities of the inoculated blended milks and the final acidities of the corresponding coagulated milks.

Starter activity was normal in each of the trials using blends of normal skimmilk and colostrum from the Holstein, Jersey, Guernsey, and Ayrshire cows. The initial and final acidity values from the four trials were averaged together and the averages are shown graphically in Figure 1.

Curd Tension

The curd tension values of coagulated milks made from blends of normal and colostrum skimmilk are presented in Table XI. The milk was coagulated entirely by acid; therefore, the curd tensions are lower than would be the case if a pepsin or rennet coagulator had been used.

The blends of normal skimmilk and Holstein colostrum exhibited a higher curd tension than normal skimmilk alone. The greater the amount of colostrum skimmilk used and the earlier it was obtained after parturition, the greater the curd tension. The colostrum skimmilk produced on the tenth day after parturition did not influence the curd tension to any great extent, except when 50 per cent was used.

The curd tension values were approximately equal in the normal skimmilk and the blends containing colostrum skimmilk secured from the Jersey, Guernsey, and Ayrshire animals.

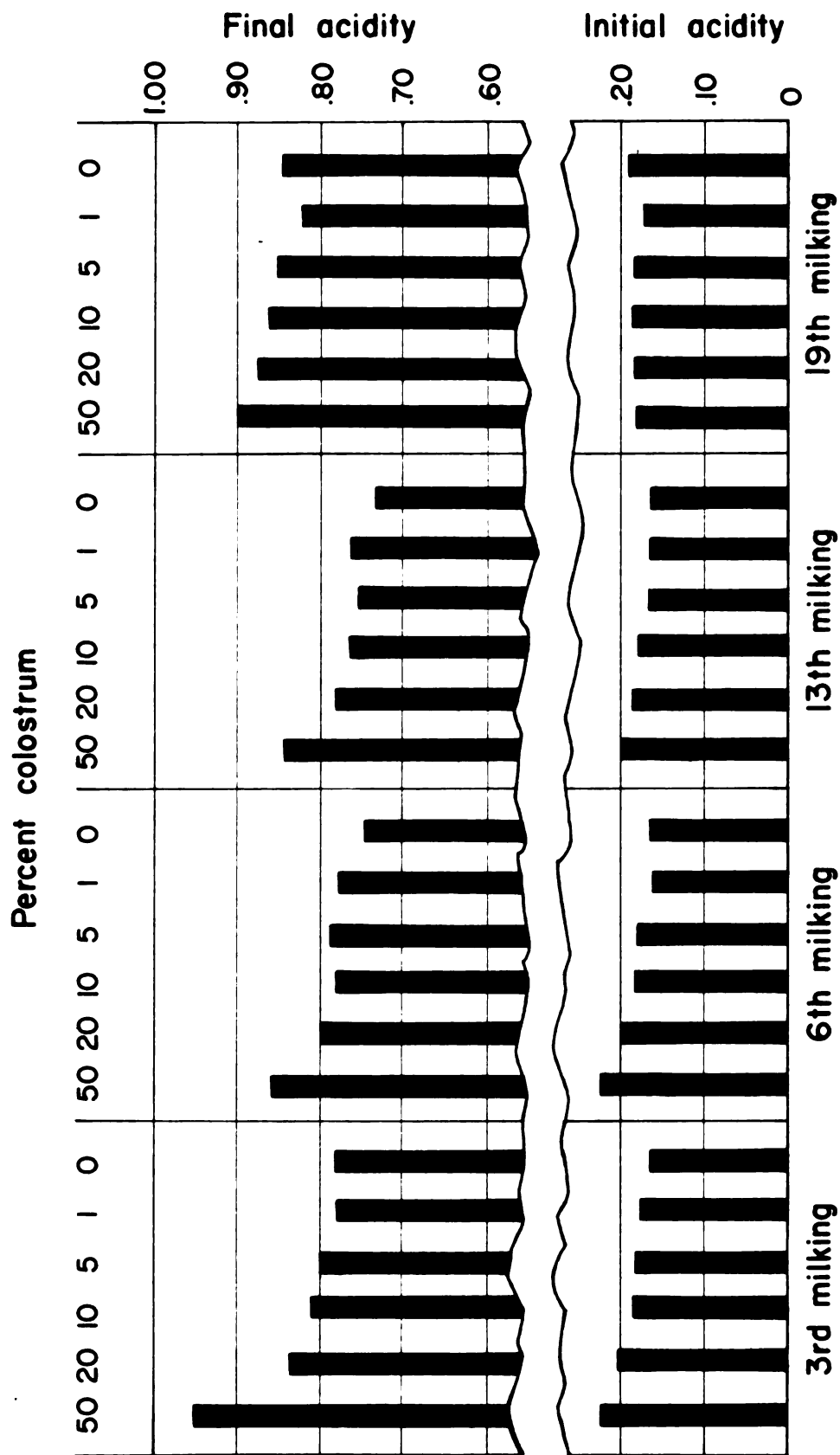


Figure 1. The initial and final acidities of coagulated milks made from normal skim milk containing 1 to 50 per cent colostrum secured intermittently during the first ten days after parturition (Values are the averages calculated from the data obtained using colostrum from four cows).

TABLE XI

CURD TENSION READINGS OF COAGULATED MILKS MADE FROM NORMAL SKIMMILK
CONTAINING 1 TO 50 PER CENT COLOSTRUM

Milking after parturition	Breed of cow	Per cent colostrum in the skimmilk						
		0	1	2	5	10	20	50
		Curd tension						
3	Holstein	35	42	48	54	62	74	
4		27	28	27	38	40	24	
5		27	30	34	30	38	54	
6		12	24	25	28	36	62	
8		52	56	57	60	67	72	
10		46	42	44	52	55	60	
11		36	34	40	40	39	50	
13		48	44	35	*	*	*	
19		38	38	38	39	42	48	
3 & 4	Jersey	16	16		18	16	16	16
10 & 11		11	11		12	12	14	18
13 & 14		12	12		13	11	14	15
19 & 20		18	**		17	16	18	**
1	Guernsey	18	18		18	20	+	+
3		15	15		16	17	13	18
5		17	18		18	19	23	25
7		11	12		**	13	14	16
13		18	20		20	23	18	23
19		35	28		27	32	30	26
1	Ayrshire	18	18		17	18	19	+
3		15	15		15	16	25	+
5		17	17		18	18	18	17
7		11	11		12	12	13	13
13		18	17		17	17	18	19
19		26	26		27	27	29	25

* Starter organisms were inhibited.

** Laboratory accident.

+ Coagulated during heat treatment.

The curd tension values from the above three trials were averaged together and the averages are illustrated graphically in Figure 2. The curd tension values from the trial using the Holstein colostrum were not included because the curd tension was not measured in the same manner as in the other three trials.

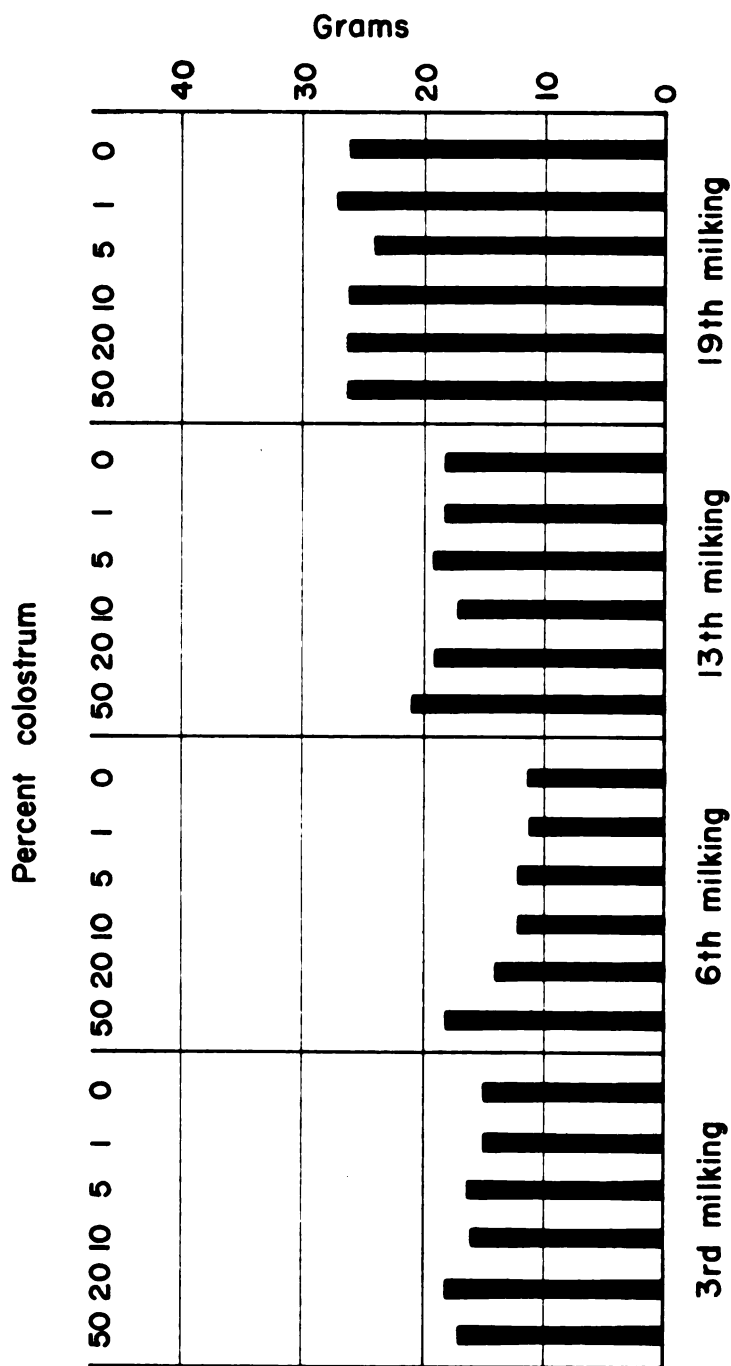


Figure 2. Curd tension measurements of skim milk containing 1 to 50 per cent colostrum skim milk secured intermittently during the first ten days after parturition (Values are the averages calculated from the data obtained using colostrum from four cows).

DISCUSSION

Cottage Cheese

Starter Activity. The starters used in this work were active in all of the vats of blended milk made from normal and colostrum skimmilk, but there were some variations in the length of time between setting the milk and cutting the curd. In 19 of the 25 vats containing a blend of normal and colostrum skimmilk, the coagulation time ranged from 25 minutes less, to 60 minutes more than the time required to coagulate the vat of normal (control) skimmilk. In 6 of the 25 blends of skimmilk, the coagulating time was from 1.00 to 3.59 hours longer than the time elapsed between setting and cutting the vats of normal skimmilk. For example, the data in Table II showed that the blended milks containing 3 per cent of colostrum secured on the seventh and tenth days after parturition required 9.67 and 8.50 hours to coagulate, respectively, as compared to 6.08 hours required by the vat of normal skimmilk. Only one of these six slow vats contained colostrum secured earlier than seven days after parturition. A statistical analyses using Fisher "t" distribution ($p = .05$) indicates that a significantly longer period of time was required before cutting the curd made from the milk containing colostrum secured on the seventh day after parturition than the curd made from the control milk. No significant differences were noted between the

control milk and the milk containing colostrum secured on the fourth or tenth day after parturition. These results suggest that an inhibitory substance may be present in colostrum and that it is more active during the latter part of the ten day interval immediately following parturition.

In the six delayed vats of curd, four were blends of normal skimmilk and 3 per cent colostrum skimmilk (Tables I and II). Apparently there was no direct relationship between the amount of colostrum present in the milk and the activity of the starter organisms.

According to Hales (11) a vat of skimmilk inoculated with 5 per cent starter will normally develop approximately 0.11 per cent acid in 2 hours and the remaining 0.21 per cent acid necessary to attain the cutting acidity should develop in approximately 1.75 hours. In one of the vats of blended milk containing 3 per cent colostrum secured on the seventh day after parturition, only 0.11 per cent acid developed in 6 hours. After the initial lag phase an additional 3.67 hours were necessary to produce the additional 0.21 per cent acid required to attain cutting acidity. The vat of blended milk containing 3 per cent colostrum skimmilk produced on the tenth day after parturition showed a similar pattern of acid development, but less time was required during the lag phase.

Approximately 7.50 hours were required to attain 0.60 per cent acid in each of the vats of milk inoculated with 6 per cent starter and coagulated without rennet. According

to Hales (11) a vat of normal skimmilk inoculated with 6 per cent starter should attain 0.60 per cent acid in 4 hours and according to Angevine (1) a similarly inoculated vat should attain an acidity of 0.50 to 0.52 per cent acid in 4.5 to 5 hours.

Some of the blends of milk contained "bloody" colostrum; however, the starter organisms were not inhibited in these milks. The results concur with the work reported by Davis (9) who observed that the presence of serum and blood in milk usually do not have a marked effect on the growth of lactic acid bacteria.

Curd Tension. Calcium chloride, which is frequently added to aid rennet in coagulating milk, was not used in this project because it was desired to secure data that would show the effect of colostrum on the curd tension of an acid-rennet curd. The curd tension was 150 grams or higher (the maximum scale reading on the curd tension meter was 150 grams) in all of the vats of normal skimmilk, except the vat of milk coagulated without rennet, in which the curd tension was only 10 grams. The appearance of several of the vats of curd immediately after cutting indicated that a curd tension of approximately 50 grams or higher was desired. The curd with a curd tension of less than 50 grams was inclined to be fragile and mushy and the curd particles were lacking in uniform size and shape. This defect is less objectionable in small curd cheese than in large curd cheese.

In 11 of the 23 blends of normal and colostrum skim-milk the curd tension of the acid-rennet coagulated milk was less than 150 grams. In eight of these eleven vats, the globulin protein content was greater in the blended milks than in the original normal skimmilk. In the remaining three of the eleven vats, the globulin protein content was normal, but delayed starter activity was apparent. However, the curd tension was not below 150 grams in each of the vats with delayed starter activity; therefore, the curd tension and starter activity probably are not directly related. These results suggest that globulin protein reduces the effectiveness of rennet in coagulating milk. This conclusion is in agreement with Ling (18) who stated that the soluble proteins, albumin and globulin, are known to retard rennet action. However, Weisberg et al. (35) added whey proteins to milk and found that the curd tension was not altered when the casein content was held at a constant level and a pepsin coagulator was added. Several workers (7, 15, 25, 35) have reported that when pepsin is used as the coagulator, the curd tension of colostrum is higher than that of normal milk. In view of these reports and the report by Ling (18), it would seem that pepsin is not inhibited by large amounts of globulin, but inhibition of rennet may occur when a limited amount of rennet is present in a large amount of globulin. Also the globulin proteins from certain individual cows may have a greater inhibitory effect on the rennet.

There are no reports in the literature that indicate the normal curd tension of milk when coagulated entirely by starter action. The curd tension of the three vats of milk inoculated with 6 per cent starter and set without rennet was approximately 10 grams at the time of cutting. The data in Table IV indicate that the yields from the vats of curd formed without a coagulating enzyme were equivalent to the yields of several vats of curd with a curd tension of 150 grams.

Yield. In this project, the average total solids content of the vats of normal skimmilk and normal skimmilk containing various percentages of colostrum skimmilk was 9.10 and 9.15 per cent, respectively. Actually the total solids content of the blended milks varied considerably, depending on the amount of colostrum included in the blends. The average amount of total solids retained in the curd made from normal skimmilk and the blended milks containing colostrum skimmilk was 37.88 and 37.83 per cent, respectively. The curd made from the blended milks containing 3, 5, 10, and 25 per cent colostrum skimmilk contained an average of 36.58, 37.59, 39.07, and 38.10 per cent of the original milk solids, respectively. The cheese made in the corresponding control vats (normal skimmilk) contained an average of 37.69, 38.50, 38.39, and 39.92 per cent, respectively, of the original milk solids. It is impossible to maintain complete uniformity in all the manufacturing procedures that affect yield. Therefore, if the experiment were

repeated, the above yields might vary slightly. However, the averages indicate that the yields from blended milks containing colostrum should be approximately equal to the yields from normal skimmilk. Data reported by Riddell et al. (25) on the average composition values of colostrum produced by various breeds of cows, showed that colostrum secured on the fourth day after parturition contained approximately 1 per cent more casein, but only 0.22 per cent more globulin than normal milk. Therefore, when colostrum is blended with normal skimmilk, the increase in total solids is primarily casein. Since about 80 per cent of the total solids material in cottage cheese is casein, the yields from blends of normal and colostrum skimmilk should be almost equal or in some instances slightly higher than the yield from normal skimmilk. The rate of change in colostrum composition varies among individual cows, and in some instances, colostrum produced on the fourth day after parturition may have a globulin content nearly equal to the casein content.

In six of the eight vats of milk in which the globulin protein content was greater than in the corresponding normal skimmilk (control), the yields were equal to or greater than the yields from normal skimmilk. These results suggest that curd tension and yield are not directly related.

Generally speaking, approximately equal amounts of total solids were lost in the whey and wash waters from each vat of cheese in a series. The amount of solids lost in the whey and in the wash waters depended on how

completely the whey was drained from the curd. Data from Table V, indicate that 57.36, 58.50, 60.52, and 58.15 per cent of the milk solids were lost in the combined whey and wash waters from the cheese. These results compare favorably with the data reported by Bender and Tuckey (6). In most instances, as the calculated per cent total solids increased, the calculated per cent total solids accounted for also increased.

Body, Texture, and Appearance. The body characteristics in a majority of the vats of finished cheese made from blends of normal and colostrum skimmilk compared favorably to the cheese made from normal skimmilk. In some instances a soft body defect was apparent in the cheese made from blends of normal and colostrum skimmilk. This soft body may have been due to insufficient cooking temperature and time.

During the early part of the cooking process there was a tendency for whey pockets to form in the curd particles made from blends of milk containing 25 per cent colostrum. Therefore, the rate of heating during the first part of the cooking procedure was decreased to allow sufficient time to expel the whey before the curd particles became firm on the outside. These whey pockets were not encountered in the curd made from blended milks containing 3, 5, and 10 per cent colostrum skimmilk. There was no significant difference in the texture of the curd made from normal skimmilk and the blended skimmilks.

The vats of curd in which the tension was 50 grams or more at the time of cutting were similar in appearance, except the curd made from the blends of milk containing "bloody" colostrum. These vats of curd had an objectionable grey color, the intensity of which depended upon the apparent amount of blood contained in the colostrum. In some instances the undesirable color was not easily detected unless the curd was compared with the curd made from normal skimmilk.

The curd particles were not uniform in size and shape when the curd tension was less than 50 grams in the vats of milk that were coagulated with and without rennet. Lack of uniformity would be less objectionable in the small curd cheese than in the large curd cheese.

Protein Analyses. Colostrum produced on the fourth day after parturition is nearly normal and caused very little change in composition when blended with normal milk, but the total, non-casein, and globulin proteins were usually slightly higher in the blended milks.

The data in Table IX showed that in four of the eight trials there was an occasional instance in which the globulin protein was greater in one of the blended milk samples. In the four remaining trials, most of the blended milk samples contained a greater amount of globulin protein than the normal skimmilk samples. In three of the latter four trials the curd tension values were lower in the blended milks than in the normal skimmilk. The data from these three trials

suggest that there may be a direct relationship between the globulin protein content and curd tension values. In the remaining trial the curd tension values were 150 grams or more in each of the three blended milk samples.

In the two series in which 25 per cent colostrum was used the blended milks contained a greater amount of globulin protein and the curd tension values were lower than in normal skimmilk.

The data in Tables I, II, VII, VIII, and IX indicate that in 10 of the 11 blended milks with a high globulin content, the time between setting and cutting the curd was equal to that of the normal skimmilk. Therefore, the globulin protein probably does not influence the rate of growth of the lactic acid organisms.

Development of Acid in Starters. Several reports in the literature indicate that colostrum contains substances inhibitory to starter organisms. In this project the blends of normal and colostrum skimmilk, that were inoculated and incubated as starters, supported the growth of lactic acid producing organisms. Rice (24) reported that lactic acid organisms would produce acid at the normal rate when they were carried in blends of milk and colostrum. He observed that milk containing 10 per cent or more colostrum had a stimulating effect on the organisms and attributed the stimulation to the high buffer value of colostrum. The data from Table X indicate that an average of 0.60 and 0.61 per cent acid developed in excess of the initial acidity in the

normal skimmilk samples and in the blended milk samples, respectively. Approximately 0.70 per cent acid will usually develop in excess of the initial acidity in milks inoculated with 1 per cent starter and incubated at 72° F. for 15 hours. A comparison of the above figures suggests that the total solids content of the normal skimmilk may have been lower than usual.

In many instances, the lactic organisms developed more acid in the blended milks than in the normal skimmilk with the acid increasing as the per cent of colostrum increased. Apparently the stimulation was due to components of the colostrum. Since the amount of stimulation definitely varied with individual cows it would seem that the stimulation may be partially attributed to the higher solids content of the colostrum. This conclusion may be further substantiated by the fact that inoculated blended milks containing colostrum from the Jersey, Guernsey, and Ayrshire cows supported starter activity better than the colostrum from the Holstein cow (Table X). Also the greatest amount of acid was produced in the blended milks containing colostrum secured nearest to parturition and the starter activity was normal in the blended milks containing this colostrum.

Curd Tension. Cultured buttermilk should have a relatively heavy body; therefore, the milk must be coagulated sufficiently to give the desired high viscosity. The curd tension test performed on the coagulated milks gave an indication as to whether milk containing colostrum would

produce the body characteristics desired of a good cultured buttermilk.

The data in Table XI show that the curd tension values of a majority of the blended milk samples were equal to or greater than the curd tension of the normal skimmilk. The higher curd tensions were attributed to the greater solids in the colostrum.

Coagulation usually occurred during heat treatment of the blended milk samples containing 20 to 50 per cent colostrum secured from the first one or two milkings. These blended milk samples undoubtedly contained large amounts of heat coagulable protein. When the samples were inoculated and incubated without heat treatment, the starter organisms produced acid at a normal rate, but the milk failed to coagulate although the acid was above 1 per cent.

Normally we expect Holstein milk to form a softer curd than Jersey, Guernsey, and Ayrshire milk. However, in this project, the data from the milk samples that were coagulated by starter showed that the curd tension values of the blended milks containing Holstein colostrum were higher than the values of the blended milks containing Jersey, Guernsey, or Ayrshire colostrum (Table XI). Two variations in laboratory procedures may be responsible for the above results: (a) the coagulated milks containing Holstein colostrum were removed from the incubator and cooled to 40° F. before the curd tension was measured, whereas the coagulated milks containing colostrum from the Jersey, Guernsey and Ayrshire were not

cooled before the curd tension was measured. (b) The same starter was not used to inoculate the blended milks containing Holstein colostrum. Since the proteolytic activity will vary among starters, the curd tension may have been influenced. Heinemann (14) reported that the proteolytic activity of starters definitely affects curd tension.

SUMMARY AND CONCLUSIONS

Thirty-three vats of cottage cheese were made from normal skimmilk and normal skimmilk containing 3 to 25 per cent by weight of milk secured during the first ten days after parturition. Analyses were made for starter activity, curd tension, yield, losses of solids in whey and wash waters, and characteristics of the finished curd. Also, starters were prepared from blends of normal skimmilk containing 1 to 50 per cent of early lactation milk. Analyses were made for starter activity and curd tension.

In most of the vats of blended milk, the starter activity was normal even when "bloody" colostrum was used and when the blended milks contained a high globulin content.

The curd tension in a majority of the vats of blended milk was 150 grams or more. The data from the vats of curd with a curd tension of less than 150 grams suggested that a high globulin protein content may limit the rennet action.

There was no significant difference in the yields from the normal skimmilk and the normal skimmilk containing 3 to 25 per cent colostrum secured during the first ten days after parturition. The yield was not affected when the blended milks contained more globulin and possessed a lower curd tension than the normal skimmilk. Evidently the casein content in the colostrum was sufficient to compensate for the globulin protein and the yields were not reduced.

The body and texture of the finished cheese were not materially affected when made from blended milks containing 3 to 25 per cent of colostrum secured during the first ten days after parturition. In a few instances the curd possessed an undesirable grey color which was attributed to the use of "bloody" colostrum. The curd particles were not uniform in size and shape when the curd tension was less than 50 grams at the time of cutting the curd.

The amounts of total, non-casein, and globulin proteins were usually slightly higher in the blended milks.

The developed acid was usually greater in the blended milks, that were inoculated and incubated as cultures, than in the normal skimmilk, with the acid increasing as the per cent of colostrum increased. Also the curd tension was usually lower in the normal skimmilk than in the coagulated milks containing colostrum. The greater starter activity and higher curd tension values were attributed to the higher total solids content of the colostrum.

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