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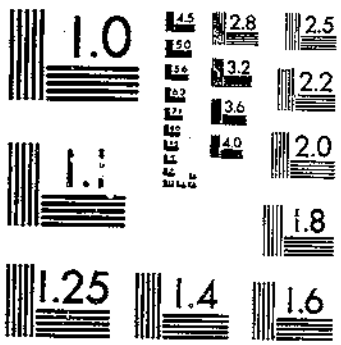

MICROCOPY RESOLUTION TEST CHART
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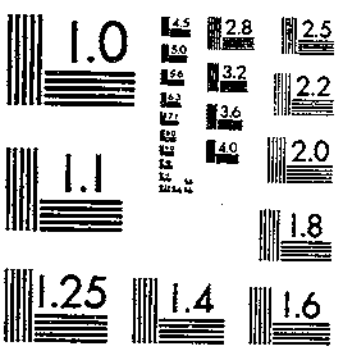

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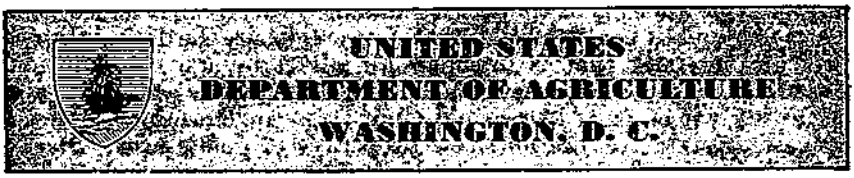

The Effect of Pasteurization on Some Constituents and Properties of Goat's Milk[1]

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INTRODUCTION

Goat's milk, because it apparently is easy to digest, has been recommended for infants, children, convalescents, and for adults troubled with digestive disturbances. Also, it sometimes is used by individuals who are allergic to other milks.

Much of the goat's milk produced in this country at present is consumed in the raw state. Goats are rarely affected with tuberculosis and for that reason the possibility of consumers contracting tuberculosis by drinking the raw milk has given little concern to public health officials. Goat's milk, however, like milk from any other source, is susceptible to contamination by various disease organisms that may be

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present during its production and handling. The consumption of raw milk may be a means of contracting undulant or Malta fever (brucellosis), and public health officials therefore emphasize the desirability of pasteurizing milk that is intended for direct human consumption. For these reasons the pasteurization of goat's milk is advocated and accordingly it becomes increasingly important to determine the effects of pasteurization on the nutritive properties of goat's milk.

The investigations reported in this publication were conducted in 1937 and 1939 by the Bureau of Dairy Industry, in collaboration with the Bureau of Animal Industry, with goat's milk that was obtained at various intervals throughout two entire lactation periods of the animals. The milk obtained during one lactation period (1937) was pasteurized by the holder method, and that obtained during the other (1939) was pasteurized by the high-temperature, short-time method. The experimental work included a study of the effect of pasteurization, by each of these methods, on the solubility of calcium and phosphorus, on proteins (extent of denaturation), on curd tension, on the keeping quality, and on the amount of reduced ascorbic acid (one form of vitamin C).

The 1937 and 1939 investigations also included a study of the adaptability of the phosphatase test to goat's milk. This revision gives more recent information on the phosphatase test as applied to goat's milk.

SOURCE OF THE MILK AND METHOD OF HANDLING

The milk used in this investigation was obtained from a herd of goats [3] maintained by the Bureau of Animal Industry, at the Agricultural Research Center, Beltsville, Md.

The herd was handled under a combination system of stall-feeding in winter and pasturing in summer. The winter diet consisted of a mixed ration of corn, oats, wheat bran, and linseed meal, with alfalfa hay and corn silage. The grazing season extended from about April 15 to October 15 with permanent pastures of mixed grasses supplemented by temporary crops of wheat, rye, barley, and soybeans being available. Grain and some hay were also fed the does while on pasture. The lactation periods extended from about the first of March to the latter part of December.

On the days when milk was collected for this investigation the morning's milk from the entire herd was thoroughly mixed as soon as drawn. A composite sample of from 1 to 2 gallons was poured into a sterilized container, which was placed in cold water for approximately 2 hours. The milk container was then packed in a metal pail surrounded by cracked ice and sent to the market-milk laboratories of the Bureau of Dairy Industry in Washington, D. C. The temperature of the milk was reduced to approximately 45° F. within 3 to 4 hours after milking. The work of pasteurization was done within approximately 7 hours after the milk was drawn. Care was taken to maintain proper conditions about the barn and to produce a milk free from odors and with a low bacterial count.

[3] This herd consisted of purebred and grade Saanen and Toggenburg goats, two breeds of milk goats popular in the United States.

PASTEURIZING TREATMENT OF THE MILK

The holder method of pasteurization, whereby milk is heated to a temperature of not less than 143° F. and held at that temperature for not less than 30 minutes, is most commonly used in this country.

When goat's milk was pasteurized by this method in this investigation, 3 temperatures were employed, 142° F., 145°, or 147°, the temperature being maintained for 30 minutes. Of a total of 25 runs made while using this method of pasteurization, 9 were made at 142°, 10 at 145°, and 6 at 147°. All runs by this method were made with the 2-liter laboratory pasteurizer shown in figure 1. Approximately 2 quarts of milk was pasteurized during each run.

The pasteurizing flask containing the cold, raw milk was first immersed in a preheating bath, which was held at 70° C. (158° F.) by thermostatic control. The milk was agitated by a glass stirrer (*b*, fig. 1) attached to an electric motor (*a*, fig. 1) revolving at approximately 200 r. p. m. When the milk had reached the desired pasteurizing temperature, the flask was transferred to another water bath held thermostatically at this temperature. After 30 minutes the flask was transferred to an ice-water bath, and the milk stirred until the temperature had dropped to 10° C. (50° F.) or lower. The milk was then transferred to storage flasks and placed in a refrigerator.

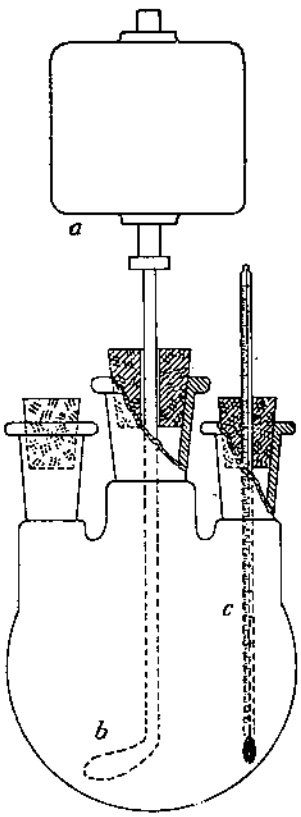

FIGURE 1.—Two-liter, three-neck flask in which goat's milk was pasteurized by holder method: *a*, Electric motor, *b*, glass stirrer, *c*, thermometer.

The high-temperature, short-time method, whereby milk is heated to 160° F. and held at that temperature for not less than 15 seconds, is also used to a large extent in this country.

Eleven runs were made by this method, with the apparatus shown in figure 2. In using this pasteurizer, the preheating coil, *c*, was immersed in a water bath held thermostatically at 165° F. (about 74° C.). The glass-tube coupler, *d*, and all tubing connecting coil *c* and the pasteurizing coil, *e*, were wrapped with cloth towels to minimize heat losses. The pasteurizing coil, *e*, was immersed in a water bath held thermostatically at 160° F. The temperature of the milk when in *d* was accurately adjusted so as to be 0.3° or 0.4° F. above the actual pasteurizing temperature to compensate for any heat loss by the milk in passing to coil *c*. The milk, under a 65-inch head, maintained by the siphon leveling device, *b*, required 15–17 seconds to pass through this coil. The rate of flow was checked at intervals by introducing a quantity of blue dye into *d*

and noting the time required for the first color to appear in a short glass tube connecting *e* with *f*, the cooling coil. The milk in passing through this coil was cooled to 10° C. (50° F.) or below, and was then collected in a glass container. All glass portions of the apparatus that might expose the milk to loss of vitamin C by sunlight were covered with paper or cloth.

Several liters of hot water were run through the pasteurizer immediately after using. The apparatus was filled with a 0.5-percent solution of sodium hydroxide for 24 hours before using. This was followed by a liter of sodium hypochlorite solution containing 200 p. p. m. of available chlorine. All traces of alkali and chlorine were washed out with sterile distilled water just before using.

STUDIES MADE ON THE MILK

Soluble Calcium and Phosphorus

The effect of pasteurization on the solubility of calcium and phosphorus was determined by estimating the relative amount of soluble calcium and phosphorus in the milk serum of the raw milk and of the pasteurized milk. The serum was prepared by passing the milk through a Chamberland-Pasteur procelain filter (porosity L–7) by

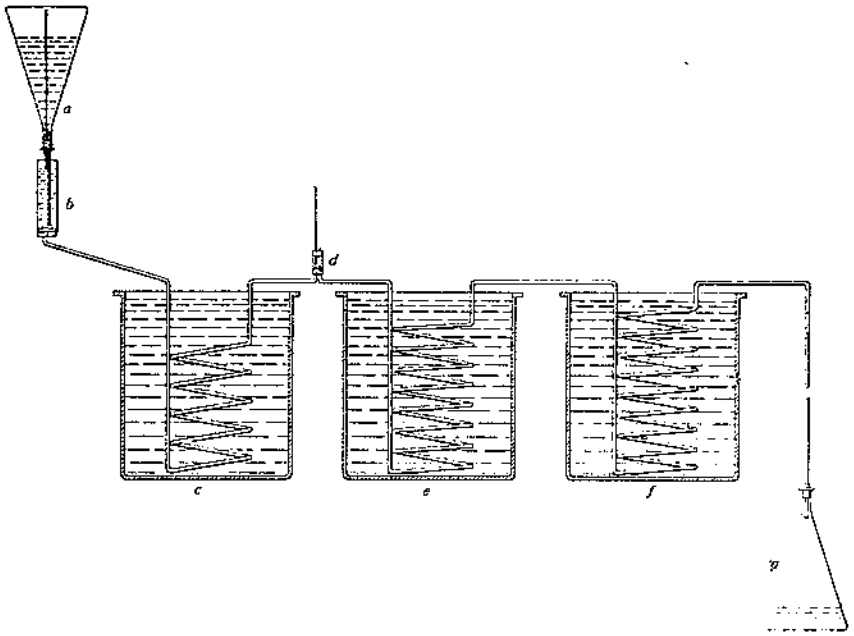

Figure 2.—Apparatus for high-temperature, short-time pasteurization of goat's milk: *a*, Reservoir (4-liter Erlenmeyer flask) for containing the cold, raw milk; *b*, siphon leveling device for maintaining a constant head (65 inches) of liquid in the pasteurizer; *c*, preheating coil (17 feet long); *d*, glass-tube coupler with thermometer to show temperature of preheated milk; *e*, the holding or pasteurizing coil (10 feet long); *f*, cooling coil (15 feet long). All coils are of pure tin block tubing, ⅛-inch internal diameter; *g*, glass container for receiving the pasteurized milk.

suction. Bacterial growth in the milk was inhibited by adding a small amount of chloroform. The serum was then placed in a refrigerator at 40°–50° F. To correct for any difference in the porosity or retentive power of a filter, it was used to filter raw and pasteurized milks on alternate filtrations.

Preliminary experiments had shown that during the initial stages of filtration some of the calcium and phosphate ions are absorbed by the filter, but that the composition of the serum remains constant after 100 ml. have passed through the filter. Therefore, in the present experiment this first portion was discarded before samples were collected for the determinations of calcium and phosphorus.

The serum was a clear, pale-yellow liquid having a faint fluorescence. It showed no evidence of turbidity under ordinary illumination, but exhibited a slight Tyndall effect. This indicated the presence of some very small colloidal particles in the serum.

Each determination of calcium and phosphorus was made on individual 50–ml. portions of the serum (20° C.; 68° F.). The serum was evaporated and ashed in platinum vessels, taken up with acid, and filtered. These filtrates were then used directly for the calcium and phosphorus determinations. Calcium was precipitated as the oxalate, and finally titrated with potassium permanganate. Phosphorus was determined by precipitating with molybdate solution, reprecipitating with magnesia mixture, and finally burning and weighing as magnesium pyrophosphate.

The effect of pasteurization on the amounts of calcium and phosphorus passing through the Chamberland-Pasteur filter is shown in table 1.

High-temperature, short-time pasteurization (table 1) reduced the amount of soluble calcium by 3.6 percent on an average for 11 and the amount of phosphorus by 3.2 percent on an average for 10 samples treated by that process. The holder method, however, caused a greater loss of solubility, the calcium being reduced 7.5 percent on an average for 21 and the phosphorus 4.7 percent on an average for 18 results obtained at the 3 holding temperatures. The change in temperature of pasteurization from 142° to 147° F. produced no definite trend in the amount of calcium or phosphorus that was rendered insoluble.

This loss in solubility was not so great as the seasonal fluctuation in the amounts of these substances in the raw milk. For instance, for the 21 milkings obtained during the lactation period in which the holder method of pasteurization was used, the calcium content averaged 0.0345 gm. per 100 ml. of raw-milk serum. The maximum for any one milking was 0.0391 gm., or 13.3 percent greater than the average, and the minimum was 0.0287 gm., or 16.8 percent less than the average. Similarly, during this lactation period the phosphorus content averaged 0.0468 gm. per 100 ml. of raw-milk serum; the maximum was 0.0596 gm., or 27.4 percent higher than the average, and the minimum was 0.0384, or 17.9 percent lower than the average. Likewise, for the milkings obtained during the lactation period in which the high-temperature, short-time method of pasteurization was used, the calcium content averaged 0.0389 gm. with a maximum of 0.0484 or 24.4 percent higher than the average, and a minimum of 0.0339 or 12.9 percent lower than the average. The phosphorus content of the raw-milk serum during this period averaged 0.0405 gm., and the maximum was

TABLE 1.—*Effect of pasteurization on the amount of soluble calcium and phosphorous in goat's milk*

Pasteurizing treatment of the milk	Calcium (Ca) per 100 ml. of serum (at 20° C.)					Phosphorus (P) per 100 ml. of serum (at 20° C.)				
	Determinations	In raw-milk serum	In pasteurized milk serum	Reduction by pasteurization		Determinations	In raw-milk serum	In pasteurized milk serum	Reduction by pasteurization	
	Number	*Gram*	*Gram*	*Gram*	*Percent*	*Number*	*Gram*	*Gram*	*Gram*	*Percent*
High-temperature, short-time pasteurization, at 160° F. for 15 seconds	11	0. 0389	0. 0375	0. 0014	3. 6	10	0. 0405	0. 0392	0. 0013	3. 2
Holder pasteurization; heated for 30 minutes at:										
142° F	8	. 0341	. 0313	. 0028	8. 2	8	. 0473	. 0453	. 0020	4. 2
145° F	7	. 0355	. 0332	. 0023	6. 5	7	. 0449	. 0422	. 0027	6. 0
147° F	6	. 0339	. 0313	. 0026	7. 7	3	. 0500	. 0486	. 0014	2. 8
Average [1]		. 0345	. 0319	. 0026	7. 5		. 0468	. 0446	. 0022	4. 7

[1] Weighted.

0.0450 or 11.1 percent higher, and minimum 0.0365 or 9.9 percent lower than the average.

Therefore it seems that the decrease in solubility of the calcium and phosphorus of goat's milk that is caused by pasteurization is insignificant. Although results obtained by different methods and techniques cannot be compared directly, the results obtained by the authors on goat's milk appear to be in agreement with the work of others on cow's milk. For instance, Dutcher (*3*)[4] reported no reduction in calcium and phosphorus in the ultrafiltrate of cow's milk after pasteurization. Similarly, Kometiani (*14*) found there was no reduction in soluble calcium and phosphorus after heating to 80°–120° C. for 30 minutes. Rupp (*26*) concluded that the soluble calcium phosphates do not become insoluble after holder pasteurization. Mattick and Hallett (*18*) found there was no significant change in diffusible phosphorus, and a loss of diffusible calcium of less than 2 percent, as a result of holder pasteurization. Bell (*1*) concluded that the losses of calcium and phosphorus by pasteurization are small. Tria and Zummo (*32*) found a reduction of 1.5 percent of calcium and 2 percent of phosphorus in the ultrafiltrate. Magee and Harvey (*17*) heated milk to 70° C. for 30 minutes and dialyzed this against running water. A 23-percent loss of calcium occurred, but since the dialysis probably would upset the equilibrium in the milk, it cannot be compared with the present and other studies where the milk was filtered. A difference in porosity of the filters used by different investigators also makes direct comparison of results somewhat difficult. Elvehjem (*4*), on the basis of animal and human feeding experiments, concluded that pasteurization does not affect the digestibility of calcium. Finally, Holland and Dahlberg (*8*) concluded that there were no significant changes in the relative amounts of $CaHPO_4$ and $Ca_3(PO_4)_2$ at pasteurization temperatures.

Soluble Proteins

The extent to which the content of soluble protein in goat's milk was denatured or rendered insoluble is shown in table 2. In making these determinations the content of total protein (casein, albumin, and globulin) and the content of casein in the raw milk was determined by analysis. The amount of soluble protein (albumin and globulin) in the raw milk was calculated as being the difference between the total protein and the total casein in the raw milk. After the milk had been pasteurized, an analysis was made in which the denatured substances were precipitated along with the casein, and the result was recorded as the amount of casein plus the amount of denatured albumin and denatured globulin. From this the amount of casein, which had already been determined from the raw milk, was subtracted to find the amount of denatured albumin and globulin. Then the approximate percentage of soluble protein that was denatured by pasteurization was calculated by comparing the amount of denatured substances obtained from the pasteurized milk with the total amount of soluble proteins in the raw milk.

[4] Italic numbers in parentheses refer to Literature Cited, p. 14.

TABLE 2.—*Extent of denaturation of soluble proteins of goat's milk by pasteurization*

Pasteurizing treatment	Determinations	Total proteins [1] in raw milk	Casein in raw milk	Albumin and globulin (by difference)	Casein, denatured albumin and denatured globulin in pasteurized milk	Denatured albumin and globulin	Percentage of the total albumin and globulin content denatured by pasteurization
	Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
High-temperature, short-time pasteurization, at 160° F. for 15 seconds	8	2.443	2.066	0.377	2.094	0.028	7.4
Holder pasteurization; heated for 30 minutes at:							
142° F.	4	2.828	2.325	.503	2.343	.018	3.6
145° F.	4	2.810	2.313	.497	2.348	.035	7.0
147° F.	4	2.845	2.383	.462	2.400	.017	3.7
Average [2]	-----	2.828	2.340	.487	2.362	.023	4.8

[1] All proteins in this table were calculated as N×6.38.
[2] Weighted.

In this work the method used for precipitating the casein from the raw milk and the casein with denatured protein from the pasteurized milk, was that of Moir (*19*). The method used to precipitate the total protein of the raw milk has also been outlined by him (*20*). The nitrogen content of these precipitates was determined by the Kjeldahl method.

High-temperature, short-time pasteurization (table 2) denatured the combined albumin and globulin approximately 7.4 percent, whereas holder pasteurization, for the three temperatures of treatment, denatured these proteins an average of 4.8 percent.

Gamble, Ellis, and Besley (*5*) have pointed out that with Moir's method for determining casein, as applied to goat's milk, some globulin may also be precipitated with the casein. This would mean that the results obtained for casein in this experiment may be too high, and those for albumin and globulin too low. Similarly, Rowland (*25*) has pointed out that the use of Moir's method for determining the total protein of cow's milk tends to give low results. If this is also the case with goat's milk, the albumin and globulin figure would be decreased still more. These changes would consequently lower the percentage of denaturation somewhat below that in table 2. It should be added that the pH of the milk was not adjusted and the fat was not removed in the present procedure as was done in the work just mentioned (*5*).

The amount of denaturation of proteins in goat's milk from pasteurization was less than the seasonal variation in the content of these soluble proteins. In milk obtained during the lactation period when the holder method of pasteurization was used, the albumin and globulin content averaged 0.487 percent. The maximum amount was 0.62 per-

cent, which was 27.3 percent higher than the average, and the minimum amount was 0.30 percent, or 38.4 percent lower than the average. Similarly, with milk obtained during the lactation period in which the high-temperature, short-time method of pasteurization was used, the albumin and globulin averaged 0.377 percent. The maximum content was 0.435 percent or 15.4 percent higher than the average, and the minimum content was 0.30 percent or 20.4 percent lower than the average.

Inasmuch as the percentage of denatured proteins in pasteurized milk was less than the seasonal variation in protein content, the denaturation effect of pasteurization appears to be of minor importance.

The results for denaturation of goat's milk are comparable to those obtained by other workers using cow's milk. Rowland (*24*), using the same methods of analysis as were used in this study, found there was an average denaturation of albumin and globulin of 10.4 percent after heating cow's milk at 63° C. for 30 minutes. Kieferle and Eisenreich (*12*) found that 2.5 to 7.5 percent of albumin coagulation was caused by high-temperature, short-time pasteurization. Holder pasteurization caused a loss of approximately 20 percent in albumin. All these studies of the latter workers were conducted with commercial pasteurizers.

Curd Tension

The effect of pasteurization on the curd tension of goat's milk was studied by measuring the curd tension of both raw and pasteurized milk with a commercial curd-tension meter. With this instrument, the curd tension was determined by the method of Hill (*7*), and also by the method suggested by the curd-tension committee of the American Dairy Science Association as reviewed by Doan (*2, p. 740*). The former method involves the use of a concentrated calcium chloride-pepsin solution and the latter method the use of tenth normal hydrochloric acid-pepsin solution for the coagulation of the curd at 95° F.±1° F.

The results of the curd-tension measurements are shown in table 3.

The results given in table 3 show that high-temperature, short-time pasteurization reduced the curd tension 5.1 percent or 6.9 percent, depending on which method of coagulation was used. The holder method of pasteurization, however, caused a considerably greater reduction. The average reduction obtained for all three pasteurizing temperatures was 38.4 percent when the Hill, or 48.4 percent when the Association method of coagulation was used. The increase in temperature of pasteurization from 142° to 147° F. produced no definite trend in curd-tension reduction as determined by the Hill method, but a definite and nearly constant increase in reduction was indicated by the Association method.

Keeping Quality

Flavor scores and bacterial counts were used to determine the effect of pasteurization on the keeping quality of goat's milk. Both the raw and pasteurized milk were scored for flavor and plated for bacteria on the day of pasteurization and on the second and fourth days after pasteurization. Enough bottled raw and pasteurized milk was kept

in a refrigerator at 40° to 50° F. to have a previously unopened bottle for each determination of flavor and bacteria. Tryptone-glucose extract, skim-milk agar was used as the medium and the plates were incubated at 32° C. for 48 hours.

The effect of pasteurization on the keeping qualities of goat's milk is shown in table 4.

TABLE 3.—*The curd tension of raw and pasteurized goat's milk, as determined with two different methods of coagulation*

HILL METHOD

Pasteurizing treatment	Determinations	Average curd-tension reading		Reduction in curd tension by pasteurization
		Raw milk	Pasteurized milk	
	Number	*Grams*	*Grams*	*Percent*
High-temperature, short-time pasteurization, at 160° F. for 15 seconds	11	17. 6	16. 7	5. 1
Holder pasteurization; heated for 30 minutes at:				
142° F.	5	13. 7	8. 5	37. 9
145° F.	6	12. 9	6. 8	47. 3
147° F.	5	13. 8	9. 9	28. 3
Average [1]		13. 4	8. 3	38. 4

ASSOCIATION METHOD

High-temperature, short-time pasteurization, at 160° F. for 15 seconds	11	14. 4	13. 4	6. 9
Holder pasteurization; heated for 30 minutes at:				
142° F.	5	7. 8	4. 7	39. 7
145° F.	6	10. 5	5. 3	49. 5
147° F.	5	12. 6	5. 5	55. 9
Average [1]		10. 3	5. 2	48. 4

[1] Weighted.

Table 4 shows that both methods of pasteurization lowered the average bacterial count of the raw milk. In both trials, the average flavor score of the raw milk dropped 3.5 and 5.5 points, respectively, in 4 days, while that of the pasteurized milk dropped only 1 or 2 points in the same period. In addition, the freshly pasteurized milk actually averaged one-half point higher in flavor score than the corresponding raw milk, in both trials.

The raw milk tended to have a goaty flavor which increased in intensity with age. The milk, after being pasteurized by either method, had a less goaty flavor than did the corresponding raw milk but a very slight astringency had developed. On aging the astringency disappeared and the intensity of the goaty flavor increased slightly.

TABLE 4.—*The effect of pasteurization on the keeping quality of goat's milk*

Pasteurizing treatment	Flavor score (range 0–25)—			Bacterial count per ml.—		
	Same day	After 2 days	After 4 days	Same day	After 2 days	After 4 days
High-temperature, short-time pasteurization, at 160° F. for 15 seconds:				*Number*	*Number*	*Number*
Raw milk [1]	19. 0	17. 5	15. 5	64, 000	437, 400	8, 027, 000
Pasteurized milk [1]	19. 5+	19. 5	18. 5	1, 010	970	1, 790
Holder pasteurization; heated for 30 minutes at 142°, 145°, or 147° F.:						
Raw milk [2]	19. 5	17. 0	14. 0	23, 500	29, 900	92, 000
Pasteurized milk [2]	20. 0	19. 5	18. 0	21	55	84

[1] Average of 11 determinations.
[2] Average of 17 determinations (5, 142° F.; 7, 145°; 5, 147°) for flavor score, and 9 (4, 142°; 2, 145°; 3, 147°) for plate count.

REDUCED ASCORBIC ACID

In this investigation the effect of pasteurization on the amount of reduced ascorbic acid contained in the goat's milk was measured by titration with standardized 2,6-dichlorophenol-indophenol of various composite samples. The samples pasteurized by the holder method were titrated with the dye after the proteins had been removed by precipitation with trichloracetic acid and metaphosphoric acid, as recommended by Rasmussen et al. (*22*) and by Musulin and King (*21*). The samples pasteurized by the high-temperature, short-time method were titrated directly with the dye as described by Sharp (*30*).

The sample of raw and pasteurized milk in each case was kept on ice, in a full, tightly capped, dark-colored glass bottle, away from contact with copper. The titrations were made within 8 to 12 hours after the goats were milked. These precautions were taken to prevent destruction of the ascorbic acid and to cut down its conversion to the oxidized form to a minimum. Another sample of the raw milk was titrated within 5 hours of the milking. The effect of pasteurization on the reduced ascorbic acid content is shown in table 5.

The results as given in table 5 indicate there was a decrease of 32.8 to 45.5 percent in reduced ascorbic acid content after pasteurization by the holder method. On the other hand, pasteurization by the high-temperature, short-time method apparently did not affect the reduced ascorbic acid.

These results are comparable to those obtained recently by other workers using cow's milk.

For example, Kon and Watson (*15*) reported the destruction of 17.9 percent of the reduced ascorbic acid by commercial holder pasteurization, and 8.9 percent when using glass or 4.9 percent when using aluminum equipment in laboratory holder pasteurization.

TABLE 5.—*The effect of pasteurization on the content of reduced ascorbic acid in goat's milk*

Pasteurizing treatment	Determinations [1]	Average content of reduced ascorbic acid per liter			Loss from—	
		Raw milk 5 hours of age	Raw milk 12 hours of age	Pasteurized milk [2]	Holding of raw milk	Pasteurization
	Number	*Milligrams*	*Milligrams*	*Milligrams*	*Percent*	*Percent*
High-temperature short-time pasteurization at 160° F. for 15 seconds	11	11.5	10.6	10.6	7.8	0.0
Holder pasteurization, for 30 minutes at:						
142° F.	4	13.2	11.7	7.8	11.4	32.8
145° F.	4	13.3	12.2	6.7	8.3	45.5
147° F.	4	13.0	12.4	7.4	4.6	40.3

[1] Each determination represents a composite sample of morning's milk.
[2] Titrated at the same time as the 12-hour raw milk.

Holmes and coworkers (*9*) reported an average loss of 18.71 percent of the ascorbic acid as a result of holder pasteurization, and, in another series of experiments (*10*), no loss as a result of high-temperature, short-time pasteurization.

Woessner, Elvehjem, and Schuette (*34*) found commercial raw milk to contain 10.9 mg. of reduced ascorbic acid per liter, while commercially pasteurized milk averaged 8.9 mg.

Sharp (*30*) on the other hand, reports only "a very slight destruction" of vitamin C by holder pasteurization.

Reedman (*23*) found 25 percent of ascorbic acid destroyed by the holder method, while Whitnah and others (*33*), using five different types of commercial holder pasteurizers, reported excessive losses of vitamin C but no significant loss was noted when the milk was pasteurized by the high-temperature, short-time method. This latter observation was also reported by King and Waugh (*13*).

The data on the percentage loss of reduced ascorbic acid in the raw milk between the time it left Beltsville in the morning and its return to Beltsville with the pasteurized samples at noon, occasionally showed a loss of 20 to 40 percent. Consequently the averaged values for raw milk given in table 5 are not entirely consistent with the results on pasteurization. Also, there was considerable variation in the values during both lactation periods, i. e., the samples titrated during the spring were from 5 to 14 mg. per liter higher in ascorbic acid than most of the samples titrated during the summer and fall.

THE PHOSPHATASE TEST

The phosphatase test has become an important means of detecting improper pasteurization of cow's milk. To determine whether the test could be used with goat's milk also, it was applied to milk heated in the

laboratory at 143° F. for periods ranging from 5 to 35 minutes. It was also applied to milk pasteurized by the high-temperature, short-time method used in this investigation. In applying the tests that were available at the time the experimental work reported in this bulletin was done, both Scharer's field test (*29*) and the Gilcreas and Davis modification (*6*) of the Kay and Graham method (*11*) were used.

When samples of fresh goat's milk were pasteurized at 143° F. for periods varying from 5 to 35 minutes, all samples passed both the Scharer and the Gilcreas and Davis modification of the phosphatase test, thereby indicating proper pasteurization. The sample heated for 5 minutes was very nearly borderline, while the sample heated for 10 minutes showed a blue color considerably less dense than the maximum allowable blue color. Milk samples heated from 15 to 35 minutes showed no blue color.

When these two modifications were applied to various samples of the milk pasteurized by the high-temperature, short-time method, all samples showed no color and therefore passed the test for proper pasteurization.

When these older modifications of the test were applied to raw goat's milk, a blue color resulted which was considerably less dense than in the case of a similar sample of cow's milk. This indicated that there was a smaller phosphatase content in the goat's milk than in cow's milk.

In 1940, after this work had been completed, Lythgoe (*16*, pp.1106–1108) reported results of experimental work in which he used the Scharer phosphatase test on goat's milk. His results appeared to confirm those obtained in this investigation.

It was apparent from the results available at that time that the phosphatase test as then conducted for detecting improper pasteurization of cow's milk was not sufficiently sensitive for detecting improper pasteurization of goat's milk, even though it did indicate the presence of raw milk when present in considerable quantity.

During 1945–48, Sanders and Sager (*27*, *28*) investigated the chemistry of the phosphatase test further and introduced an improved test which they applied to virtually all dairy products, including goat's milk. In quantitative experiments, they found that the phosphatase activity in goat's milk normally is less than one-tenth of that in cow's milk. Their improved test is more sensitive and more complete than the older tests mentioned above and, in addition, they developed a special modification for testing goat's milk, utilizing a larger sample and a longer period for the enzyme to act in the test. They found also that the sensitivity could be increased by making a two- to four-fold increase in the concentration of substrate, disodium phenyl phosphate, in the test. Whereas the Sanders-Sager test for cow's milk will detect the addition of less than 0.1 percent of raw cow's milk added to properly pasteurized cow's milk, the special test for goat's milk will detect the addition of approximately 0.3 percent of raw goat's milk added to properly pasteurized goat's milk. While not so sensitive as the test conducted on cow's milk, the special test devised for use on goat's milk is sufficiently sensitive to detect improper pasteurization of goat's milk with reasonable accuracy.

SUMMARY AND CONCLUSIONS

Some constitutents and properties of goat's milk are altered slightly by the high-temperature, short-time method and holder method of pasteurization.

The solubility of calcium and phosphorus is only slightly decreased by pasteurization. The average decrease in this study was less than the normal seasonal variation in calcium and phosphorus content.

The soluble (albumin and globulin) protein fraction is not appreciably denatured by pasteurization. In this study, the average percentage of loss by denaturation was less than the normal variation in soluble protein content.

The curd tension is reduced considerably by holder pasteurization and only slightly by high-temperature, short-time pasteurization.

The flavor of fresh goat's milk is improved slightly and the keeping quality is improved considerably by pasteurization.

The older phosphatase tests, which were devised for the detection of improper pasteurization of cow's milk, were not sufficiently sensitive for application to goat's milk, because goat's milk exhibits only a small fraction of the phosphatase activity present in cow's milk. The improved phosphatase test developed by Sanders and Sager includes a special test for goat's milk which, while not as sensitive when used on goat's milk as their improved test used on cow's milk, is now considered sufficiently sensitive to detect improper pasteurization of goat's milk with reasonable accuracy.

In this study, pasteurization of goat's milk by the holder method caused a decrease of from 33 to 45 percent in the content of reduced ascorbic acid. Pasteurization by the high-temperature, short-time method apparently did not affect the ascorbic acid.

The effect of pasteurization on the solubility of calcium and phosphorus, on the denaturation of proteins, and on the ascorbic acid content of goat's milk are comparable to the effects of pasteurization on the same constituents in cow's milk, as reported by other investigators.

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