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Goats' Milk: Manufacturing Aspects for Long Time Preservation

FREDERIC W. DOUGLAS, JR., V.H. HOLSINGER, E.J. GUY, P.W. SMITH AND F.B. TALLEY

Eastern Regional Research Center, Agricultural Research Service, U.S. Department of Agriculture, 600 East Mermaid Lane, Philadelphia, Pennsylvania 19118

SUMMARY: Processing parameters affecting the physical stability and flavor of three processed whole goats' milk products were investigated. Frozen concentrates with storage stability of up to ten months were processed by concentrating high-temperature-short-time pasteurized milk with 26% or 52% of its lactose in hydrolyzed form to 3:1 or 4:1, post heading at 71°C for 30 minutes, adding antioxidant, freezing, and storing at $-14°C$. These concentrates could be thawed and refrozen up to three times without destabilizing. It was necessary to add antioxidant to maintain taste quality; treated samples developed less oxidized and bitter flavors and less goatiness over the storage period than did the untreated controls.

The storage properties of ultra-high-temperature (UHT) processed single strength and concentrated (2:1) shelf stable milks with and without 1% added sodiumhexametaphosphate as stabilizer were evaluated. Best physical stability was observed in an unstabilized pasteurized sterilized milk, suggesting that a stabilizer commonly used in evaporated cows' milk is not suitable for goats' milk.

Hedonic ratings of air-packed spray-dried whole goats' milk powder given a special pasteurization for six minutes at 76.6°C before homogenizing, condensing, and spray-drying, decreased abruptly after 127 days of storage at 25°C. This decrease correlated with a sharp increase in oxidized flavor criticisms.

Although all three products showed good physical stability, only the frozen concentrates maintained acceptable flavor ratings over the entire storage period when reconstituted with water into beverage milk.

KEY WORDS: Goats' milk; UHT processing; Frozen concentrates; Spray-drying; Flavor; Physical stability; and Pasteurization.

Introduction

Supplies of goats' milk are seasonal with the greatest quantity available in the spring and summer months. Improved feeding and breeding practices have helped to level off the peaks and valleys in milk production, but problems related to supply and demand still exist. Fresh goats' milk and its products are usually marketed in health food stores, drug stores and supermarkets (Guy, 1982). Since fresh goats' milk is distributed in small quantities it incurs high transportation and handling costs. Consequently, long-term preservation is desirable not only to insure a year-round supply to the consumer but to open new markets in areas where fresh goats' milk is unavailable.

Loewenstein, *et al.*, (1980) in their review stated that there are little data available on the manufacture of fluid goats' milk products such as low fat, fortified, or flavored milks, cultured products such as buttermilk or yoghurt; frozen products such as ice cream and frozen yoghurt; butter; condensed milk or dried milk products. There are ample data available for the manufacture of these products from cows' milk, but transposing the manufacturing techniques to goats' milk is not always possible.

This study was undertaken to evaluate the processing parameters necessary to prepare goats' milk products that would have good physical stability during long-time storage and would have beverage milk characteristics after reconstitution with water.

Materials and Methods

Milk

Goats' milk for these studies was obtained from Pure Goat Products, Inc., Boyertown, Pennsylvania, to which about 30 producers ship fresh milk. Fresh cows' milk was obtained from Walebe Farms, Collegeville, Pennsylvania.

Commercial whole evaporated and whole spray-dried goats' milk powder were purchased both from local health food stores and directly from the manufacturers.

Miscellaneous materials

Food grade "Maxilact" enzyme was purchased from Enzyme Development Co., New York, New York. Tenox-6 was purchased from Eastman Kodak Co., Rochester, New York and sodium hexametaphosphate (NaHMP) was purchased from J.T. Baker Co., Phillipsburg, New Jersey.

Organoleptic studies

Organoleptic evaluations were carried out in a controlled tasting room and supervised by an experienced panel administrator. Panelists were experienced cows' milk product judges who did not receive any additional training for judging goats' milk products. For evaluation, samples were reconstituted with distilled water to 11%-12% total solids, held in the refrigerator overnight, and warmed to room temperature before tasting. Flavor evaluation forms used were a five-point intensity scale with scores ranging from 0 = none, 1 = questionable, 2 = slight, 3 = distinct and 4 = strong (Figure 1), and a nine-point hedonic scale (Peryam and Pilgrim, 1957), which ranges from "dislike extremely" to "like extremely" (Figure 2). Composite average scores were usually based on ratings by 10 experienced panelists. Statistical evaluations for significance were made by anaysis of variance and Duncan's Multiple Range Test.

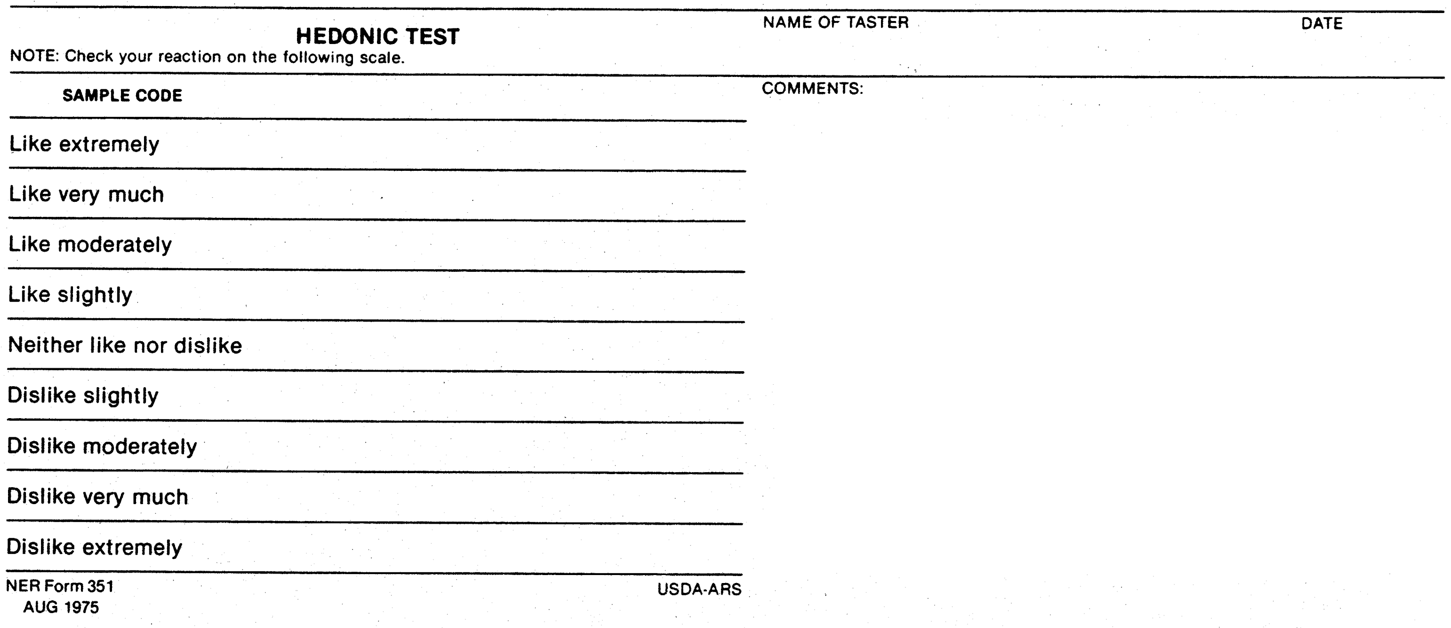
SCALE

0 = None
1 = Questionable
2 = Slight
3 = Distinct
4 = Strong

Please use one of the above numbers to describe the intensity of each flavor listed below.

Flavor Criticism	Sample Code
Cooked	
Feed	
Rancid	
Stale	
Oxidized	
Other	

Figure 1. Flavor evaluation form used by a panel of experienced cow's milk product Judges to evaluate goat milk.



HEDONIC TEST

NOTE: Check your reaction on the following scale.

NAME OF TASTER

DATE

COMMENTS:

SAMPLE CODE

Like extremely

Like very much

Like moderately

Like slightly

Neither like nor dislike

Dislike slightly

Dislike moderately

Dislike very much

Dislike extremely

NER Form 351
AUG 1975

USDA-ARS

Figure 2. Form used by a panel of experienced cow's milk product Judges for hedonic evaluation of goats' milk and goats' milk products.

Analyses

Lactose was determined colorimetrically in untreated milk by reduction of copper salts in alkaline Fehling's solution using USP lactose hydrate for the standard curve instead of glucose (Folin and Wu, 1919). Lactose crystallization was determined accordingly to the technique of Tumerman, *et al.*, (1954) using the Sharp and Doob (1941) procedure. The method of Tauber and Kleiner (1932) was used to determine monosaccharides in the presence of lactose.

Sedimentation indices were measured on all powders and fluid milks with a modification of the official procedure for whole dry milk (American Dry Milk Institute, 1947) and solubility index was reported as ml of sediment per 50 ml of reconstituted milk.

For the measurement of bulk density, the procedure in Methods of Laboratory analysis (1961) was used and results reported as g per ml.

Sinkability was used as a measure of wettability of the powders and was determined by the procedure of Bullock and Winder (1960).

Dispersibility was measured on all powders with the procedure of Sinnamon, *et al.*, (1957) as modified by Kontson, *et al.*, (1965).

Whey protein nitrogen determinations were by the Methods of Laboratory Analysis for Dry Whole Milk, Nonfat Dry Milk, Dry Buttermilk, and Whey (1961), with a modification of the Harland-Ashworth test (1945) used for whey protein nitrogen.

Chemically available lysine was determined by the method of Kakade and Liener (1969) as modified by Greenberg, *et al.*, (1977).

Frozen-concentrates

Fresh raw whole goats' milk was pasteurized at 76°C for 15 seconds (High-temperature-short-time) (HTST) and homogenized double-stage at 105.5-35.2 kg/cm^2. Lactose was hydrolyzed to 52% with 0.0175% lactase enzyme for two hours at 30°C. Enzymatic reaction was stopped by repasteurizing the samples. Samples were concentrated to 3:1 or 4:1 in an APV recirculating vacuum batch evaporator and in one instance NaHMP was added. Concentrates were post-heated at 71°C for 30 minutes. Tenox-6 was added, samples were canned, frozen, and stored at – 14°C.

Ultra-high-temperature-(UHT)-milk

Single batches each of raw whole goats' and cows' milk were processed similarly by sterilizing in a CP Ultra Therm Sterilizer at 141.1°C for 4s (HTST), homogenized double-stage at 105.5-35.2 kg/cm^2, cooled and canned aseptically in an ethylene oxide sterilized glove box under sterile nitrogen (Raw sterilized samples = RS). The remaining cows' and goats' milks were each pasteurized at 124°C for 15s (HTST) and each split into two lots. One lot each of cows' and goats' pasteurized milk was processed as the raw-sterilized samples (Pasteurized-sterilized samples = PaS). The remaining pasteurized milks each were concentrated in an APV recirculating vacuum batch evaporator to ~30% total solids (T.S.), standardized to 25.5% T.S., sterilized, homogenized, cooled, and canned as above (pasteurized-concentrated-sterilized samples = PaCS). The processing procedure was repeated with the addition of 290.6 g of NaHMP per 45.4 kg of T.S. to each milk before processing. Samples were stored at room temperature (~23°C) and 4.4°C.

Spray-dried whole goats' milk powder

Raw whole milk was pasteurized at 76.7°C for six minutes, cooled to 60°C, homogenized at 175.8–35.2 kg/cm^2, condensed to about 45% T.S. in an APV recirculating vacuum bath evaporator, standardized to 40% T.S., and spray-dried with a Bowen Engineering, Inc. table model laboratory spray dryer equipped with a water-cooled spinning disc atomizer. Cows' milk was carried through the same processing procedure for use as a control. Powders were canned with part of each powder being packed under nitrogen and stored at −14°C as controls and the remainder air-packed and stored at room temperature.

Results and Discussion

Lactose-hydrolyzed frozen goats' milk concentrates

The freezing of 3:1 or 4:1 concentrates has been regarded for years as a highly attractive method of preserving cows' milk. When reconstituted, such milks have a flavor initially indistinguishable from fresh milk. The problem with them has been a tendency to thicken and coagulate on storage because of crystalization of the lactose which has been brought to its saturation point by the concentration. Partially hydrolyzing the lactose (Tumerman, *et al.,* 1954), post-heating the concentrate (Bratz and Winder, 1959), adding sodium hexamethaphosphate (Don and Warren, 1947), and adding Tenox-6 as an antioxidant proved to be processing parameters that increased physical stability of frozen goats' milk concentrates (Guy, 1982). Preservation of goats' milk in this form would be a feasible way to increase goats' milk distribution year-round.

Tenox-6, an antioxidant which reduces the development of oxidized off-flavors in cows' milk (Johnson, 1970) was tested for its effect on flavor stability of frozen concentrated goats' milk during storage. When added at a level of 0.01 g/100 g fat to 4:1 (48% T.S.) 52% lactase-hydrolyzed goats' milk concentrates, the hedonic flavor score after reconstitution was maintained during the ten-month storage period (Table 1). Because the total number of panelists was limited, in part due to adverse bias against the product, rigid panel selection was not practical, even though several members were experienced dairy product judges. With the limitation of time and samples for repeat testing, oxidized and bitter flavors were not analyzed statistically (Tables 1 and 2). Oxidized and bitter flavors were less intense than those of the untreated control sample and "goaty" flavor remained relatively constant over the storage period. Although "goaty" flavor scores were statistically analyzed, because

Table 1. Effect of Tenox-6 on hedonic rating and intensity of oxidized and bitter, and goaty flavor scores of 52% lactose-hydrolyzed 4:1 (48% T.S.) frozen concentrated goats' milk.

	Hedonic		Oxidized and bitter		Goaty	
Age months	Control	Tenox-6	Control	Tenox-6	Control	Tenox-6
Initial	5.12	5.26	0	0	1.16	1.16
2	6.25	6.25	0	0	1.66	1.25
4	5.68	6.12	0.56	.20	1.00	1.25
6	5.72	5.72	0.44	0.12	1.29	1.29
8	5.06	5.72	0.66	0.12	1.06	0.55
10	5.06	6.68	0.75	0.20	0.50	0.71

of the range of scores obtained and the limited number of panel members, no significant differences in scores were obtained for any one testing (Tables 1 and 2). Tenox-6 appeared to have no effect on "goaty" flavor. Data for 26% lactase-hydrolyzed samples are not shown here because the percentage of lactase hydrolysed (26% or 52%) did not affect the acceptability of the samples.

Polyphosphates are frequently added to HTST sterile concentrated cows' milks to stabilize them both against heat coagulation during sterilization and gelation during storage (Leviton, *et al.*, 1963). The addition of NaHMP (0.4%) to goats' milk not lactase-hydrolyzed resulted in 3:1 frozen concentrates which had improved physical stability (Table 2). The percentage of lactose crystallization was reduced initially and through two months but increased during the fourth month and was lower than the control for the remaining storage period. Viscosity built-up was greatly reduced by the addition of NaHMP after the second month of storage. Hedonic flavor scores were reduced which can be attributed to the increased oxidized, bitter and "goaty" flavors. Because of the effect of NaHMP on the organoleptic quality, even though it improves the physical stability, we recommend that it not be added to goats' milk concentrates which are to be frozen.

Table 2. Effect of sodium hexametaphosphate (NaHMP) on physical stability and flavor of 3:1 concentrated goats' milk.

					Flavor ratings					
	%Lactose crystallized		Viscosity (CPS)		Hedonic		Oxidized-bitter intensity		Goaty intensity	
Storage (months)	Control	NaHMP	Control	NaHMP	Control	NaHMP	Control	NaHMP	Control	NaHMP
0	0	0	18.8	22.6	6.25	5.86	0.11	0.55	1.56	1.77
2	57	0	145	28	5.42	5.85	0.12	0.62	1.60	1.60
4	51.5	71	318	200	5.33	4.58	0.41	0.75	1.50	1.60
6	89	81	1720*	257	5.85	4.42	0.85	0.85	1.10	1.40
8	95	79.5	2100*	435	4.25	4.12	0.66	1.86	0.44	1.00
10	—	86	—	688	—	3.50	—	1.89	—	0.75

*Coagulated

Ultra-high-temperature sterilized goats' milk

Interest in sterilized milk products has increased since UHT-sterilization processes have been developed; the subject has recently been reviewed by Mehta (1980). Preliminary work by Ormiston and Herreid (1965) indicated that sterilization at 148.9°C destabilized the proteins in goats' milk resulting in a settling of the solids during storage. UHT-sterilization brings about a number of changes in the various protein fractions of goats' milk (Douglas, *et al.*, 1981) (Langsprud and Hadland, 1971), but from a bacteriological point, UHT-processed milk is safe (Burton, 1969). The tendency of the milk to coagulate can be controlled somewhat by the correct choice of processing temperatures (Samuelson and Holm, 1966). Gel formation is a very important factor in UHT-processed milk because it determines the storage time. UHT-processing increases sensitivity to coagulation compared to autoclave sterilization (Burton, 1969).

Since evaporated whole goats' milk was available commercially in our area, we began our investigation of the properties of UHT-processed goats' milk by purchasing this product from local sources in order to evaluate its physical properties and flavor quality as a beverage product.

Flavor evaluation of fresh pasteurized cows' and goats' milk each received a score of "like slightly" to "like moderately" on the hedonic scale (Table 3). Commercial evaporated goats' milk, samples 1 and 2 scored between "dislike extremely" and "dislike very much"; however, these samples were 614 and 184 days old, respectively. Samples 1A and 2A scored between "dislike very much" and "dislike moderately." On the five-point intensity rating scale "goaty" flavor of the fresh pasteurized samples was less than "questionable" whereas all of the commercial samples except 2A scored a "slight plus." Solubility index and relative viscosity were higher in the 184-day old commercial sample suggesting that this sample was less stable than the others.

Table 3. Flavor and physical properties of commercial evaporated whole goats' milk[1].

Sample	Age (days)	Hedonic	Goaty (intensity)	Solubility index[2] (ml)	Relative viscosity (centipoise)
Goats' milk	Fresh	6.33	0.67	<0.10	2.60 ± 0.43
Cows' milk	Fresh	6.44	0.40	—	—
Commercial 1	614	1.33	2.33	0.01	6.75 ± 0.43
Commercial 1A	56	2.56	2.11	0.05	6.53 ± 0.63
Commercial 2	184	1.44	2.33	0.25	16.20 ± 0.18
Commercial 2A	15	2.33	1.56	0.10	10.20 ± 0.09

[1] Means ± standard error of means.

[2] Means of duplicates.

Thus, with the above observations in mind we processed cows' and goats' milk with added NaHMP to determine whether the physical stability and flavor of UHT-goat's milk could be improved.

Physical stability of experimental UHT-processed samples was measured by change in relative viscosity. Viscosity of the unstabilized (PaCS) concentrate decreased after six months, but viscosity of the NaHMP stabilized (PaCS) concentrate increased sharply after only four months of storage (Table 4). The fluid milk samples had relatively constant values over the storage period.

Hedonic flavor scores of both the NaHMP stabilized and unstabilized samples decreased significantly after six months storage (Table 5).

NaHMP stabilized samples received the best hedonic ratings initially, but after six months at 25°C ratings received by the two stabilized fluid milks were below those received by the unstabilized samples. "Goaty" flavor intensity was relatively constant over the six-month storage period with the least amount in the stabilized and unstabilized concentrate. This is probably due to the removal of volatiles during the concentration step. The raw sterilized unstabilized sample had no bitter intensity score, whereas all of the other samples scored "questionable" or less. Cooked flavor intensity was less than "questionable" in all samples except the stabilized raw-sterilized and pasteurized-sterilized samples which had none. Only the stabilized pasteurized-concentrated-sterilized sample had a caramel flavor intensity and it was less than "questionable." A staleness intensity was scored only in the unstabilized

Table 4. **Relative viscosity of experimental UHT-processed goat milks.**[1]

	Centipoise			
Sample	Initial	2 Months	4 Months	6 Months
		Unstabilized		
Raw sterilized	2.58 ± 0.33	2.67 ± 0.37	2.50 ± 0.33	2.53 ± 0.24
Pasteurized sterilized	2.42 ± 0.37	2.68 ± 0.34	2.55 ± 0.30	2.15 ± 0.31
Pasteurized concentrated sterilized	7.92 ± 0.46	5.58 ± 0.44	5.23 ± 0.56	4.52 ± 0.17
		Stabilized With Sodium Hexametaphosphate		
Raw sterilized	2.82 ± 0.28	4.23 ± 0.31	3.53 ± 0.10	3.11 ± 0.19
Pasteurized sterilized	3.03 ± 0.23	2.50 ± 0.38	2.33 ± 0.12	4.12 ± 0.23
Pasteurized concentrated sterilized	7.00 ± 0.52	4.63 ± 0.45	>100	>100

[1] Stored at 25°C. Triplicate readings at 30 and 60 rpm.
Means ± standard error of means.

Table 5. **Hedonic and intensity of selected off-flavors in NaHMP stabilized and unstabilized experimental UHT-processed goats' milk**[1]**.**

	Hedonic		Off-flavor intensity after 6 months				
Samples	Initial	6 Months	Goaty	Bitter	Cooked	Caramel	Stale
			Unstabilized				
Raw sterilized	3.18	2.40	2.50	0	0.70	0	0.40
Pasteurized sterilized	3.73	2.00	2.30	0.40	0.60	0	0
Pasteurized concentrate sterilized	2.90	2.30	1.90	0.50	0.80	0	0
			Stabilized With Sodium Hexametaphosphate				
Raw sterilized	4.11	1.38	2.75	1.00	0	0	0
Pasteurized sterilized	5.00	1.88	2.38	0.50	0	0	0.25
Pasteurized concentrate sterilized	4.22	2.88	1.88	0.38	0.63	0.38	0.75

[1] Samples stored at . . . 25°C.

raw-sterilized sample and the stabilized pasteurized-sterilized and the pasteurized-concentrated-sterilized samples.

Although the physical stability as measured by relative viscosity of the NaHMP stabilized concentrate decreased as the storage time increased, all of the fluid samples, unstabilized and stabilized, remained relatively unchanged over the six-month storage period. The data are not shown but cooked and caramel off-flavors were more prevalent in the cows' milk control sample than in the goats' milk.

Spray-dried whole goats' milk powder

With the improvement in drying and packaging technology over the past 40 years, the conversion of milk, especially skimmed milk, to powder has become a common means of preservation for long-term storage.

Because powdered goats' milk was available, we began our investigation of the properties of spray-dried goats' milk powder by purchasing commercial powders to evaluate their flavor quality as a beverage product.

The average hedonic flavor ratings of the reconstituted powder compared to fresh pasteurized cows' and goats' milk were obtained with the same nine-point hedonic rating scale described previously (Table 6). The average hedonic scores for both powders fell between the "dislike very much" and "dislike extremely" categories of the rating sheet, whereas the fresh goats' milk received a score equivalent to that of fresh cows' milk. The low hedonic rating may have been due to the age of the powders. Powder A was 645 days old and powder B was 506 days old when tasted.

Table 6. Hedonic ratings and intensity of selected flavors of commercial whole goats' milk powder.

Sample	Hedonic	Goaty	Oxidize bitter	Rancid	Cooked stale
Fresh pasteurized cows' milk	6.88 ± .66	0	0.22	0	1.00
Fresh pasteurized goats' milk	6.33	0.44	0.11	0	1.56
Powder A	1.89	1.44	2.89	0	1.00
Powder B	2.00	1.33	0.89	1.67	1.44

Because of the presence of the lipid component, powdered whole milk is subject to the development of a variety of undesirable strong off-flavors during storage, chiefly rancid, oxidized or tallowy and stale. Samples were rated using the five-point intensity scale. Both powders received significantly higher ratings for "goaty" flavor than did the fresh goats' milk sample. In addition, goats' powder A received a significant rating for oxidized flavor; goats' powder B is packed in inert gas, so oxidized flavor did not develop in this sample. However, powder B was distinctly rancid. All samples received equivalent ratings for cooked and stale flavors.

We were concerned about the poor flavor ratings given the commercial spray-dried powders because they are high-priced, selling for about $8.50/pound in our area. Therefore, we decided to examine the effects of some processing parameters on the reconstitutability and storage stability of whole goats' milk powder.

Tamsma, *et al.*, (1962) showed that heating cows' milk in excess of pasteurization requirements prior to drying conferred stability against oxidative change of spray-dried whole milk during storage. It is believed that oxidized flavor development in the powder is retarded by heat treatment because of the reducing conditions, that is, activation of the sulfhydryl groups of the major whey protein, β-lactoglobulin, generated in the product by the heating. We studied the effects of processing sequence on hedonic flavor ratings on experimental samples taken during processing (Table 7). Raw goats' milk received the lowest hedonic rating, 4.12; the heat treatment improved the rating to 5.0 and condensing under vacuum improved the rating further to 5.62, suggesting that volatile materials contributing to the off-flavor were removed. The score decreased again to 4.87 as a result of drying which is higher than the raw milk score, suggesting that processing does improve acceptability. Cows' milk showed a different trend; heat treatment decreased acceptability from 7.3 to 5.25. However, the concentration step significantly improved the rating to 6.75 but drying reduced the rating slightly to 6.25.

Table 7. Effect of processing on hedonic and intensity of selected flavors of goats' and cows' whole milk.

Sample	Hedonic	Goaty	Cooked
	Goat		
Raw	4.12	1.25 ± .46	0
Pasteurized	5.00	1.50	0.75
Pasteurized and homogenized	5.00	1.63	0.37
Concentrated	5.62	1.25	0.25
Spray-dried	4.87	1.62	0.25
	Cow		
Raw	7.37	0.25	0.38
Pasteurized	5.25	0.13	2.25
Pasteurized and homogenized	5.62	0.13	1.88
Concentrated	6.75	0.13	0.50
Spray-dried	6.25	0.13	1.00

Dominant off-flavors identified by the judges in the samples were "goaty" and "cooked." We cannot explain the low hedonic score of the fluid goats' milk because the data listed here showed that processing had virtually no effect on "goaty" flavor; all ratings fell between the "questionable" and "slight" categories of the intensity rating sheet.

In contrast to cows' milk, heat treatment did not result in a strong cooked flavor in the goats' milk product. Some judges also identified an oxidized off-flavor in some of the goats' milk samples but all scores fell into the "questionable" category.

In both cows' and goats' milk samples a sharp decrease of the hedonic flavor rating of the reconstituted experimental powders stored for six months at room temperature was observed after 127 days (Table 8). This decrease can be explained by a significant increase in oxidized flavor ratings in both sample sets (Table 9). Because this increase also occurred in the nitrogen-packed samples, it is evident that under the conditions used, the gas-packing equipment was not adequate to reduce the in-can oxygen to a level sufficiently low to prevent oxidative changes during storage, even in the freezer. A significant increase in rancid flavor criticisms was observed in the goats' milk powder after 169 days of storage, suggesting that there might be residual lipase activity in the powder. No similar observation was made for cows' milk powder.

Table 8. Hedonic flavor ratings of experimental powders stored 6 months.

	Cow		Goat	
Storage time days	N_2 pack -14°C	Air pack 25°C	N_2 pack -14°C	Air pack 25°C
Initial	6.25	—	4.87	—
45	5.78	5.56	4.90	4.90
90	5.30	5.60	4.30	4.20
127	4.22	3.78	2.11	2.44
169	3.90	3.30	3.87	2.62

Table 9. Oxidized and rancid flavor ratings of exerimental powders stored 6 months.

	Oxidized				Rancid			
	Cow		Goat		Cow		Goat	
Storage time days	N_2 pack -14°C	Air pack 25°C	N_2 pack -14°C	Air pack 25°C	N_2 pack -14°C	Air pack 25°C	N_2 pack -14°C	Air pack 25°C
Initial	0	—	0.25	—	0	—	0.25	—
45	0.22	0	0.40	0.70	0	0	0	0
90	0.60	0.60	0.40	0.30	0.10	0.20	0	0.10
127	1.11	1.00	1.67	1.11	0	0	0.56	0.33
169	1.50	1.70	1.25	1.00	0	0.10	0.63	0.88

The average ratings for "goaty" flavor were quite variable in the nitrogen-packed samples of goats' milk powder; however, in the air-packed samples, there was little change in "goaty" flavor intensity over the storage period (Table 10). These data, coupled with those from the samples taken during processing (Table 7), seem to indicate that the "goaty" flavor present initially, changes very little during powder manufacture and storage. The intensity of cooked flavor declined steadily over the storage period in the cows' milk powder but showed no change over the initial low rating of 0.25 for the goats' milk powder. Lactone flavor ratings increased steadily over the storage period in all samples.

The drying of fresh milk for preservation purposes is only advantageous if the dried product can be readily reconstituted with water by the consumer into a fluid product with the properties of the original milk. Therefore, we investigated some

Table 10. Goaty, cooked, and lactone flavor ratings of experimental powders stored 6 months.

	Goaty				Cooked				Lactone			
	Cow		Goat		Cow		Goat		Cow		Goat	
Storage times days	N$_2$ pack −14°C	Air pack 25°C	N$_2$ pack −14°C	Air pack 25°C	N$_2$ pack −14°C	Air pack 25°C	N$_2$ pack −14°C	Air pack 25°C	N$_2$ pack −14°C	Air pack 25°C	N$_2$ pack −14°C	Air pack 25°C
Initial	0.13	—	1.62	—	1.00	—	0.25	—	0.13	—	0	—
45	0.44	0.33	0.80	0.90	0.56	0.78	0.60	0.30	0.56	0.78	0.40	0.90
90	0.20	0.50	1.80	1.40	0.80	0.90	0.20	0.40	0.70	1.20	0.70	1.20
127	0	0	2.22	1.11	1.11	0.78	0.67	0.22	0.44	0.78	0.33	0.78
169	0.40	0.70	1.00	1.00	0.20	0.30	0.25	0.38	1.30	1.40	1.50	1.88

Table 11. Rehydration properties of goats' and cows' whole milk powders[1].

	Commercial (Goat)		Experimental	
	A	B	Goat	Cow
Bulk density (g/100 cc)	29.90 ± 0.02	48.6 ± 0.10	31.40 ± 0.30	33.95 ± 0.15
Solubility index (ml)	0.20 ± 0.0	0.10 ± 0.0	0.05 ± 0.0	0.20 ± 0.0
Dispersibility (%)	74.82 ± 0.44	73.76 ± 0.63	57.54 ± 0.57	66.60 ± 0.26
Sinkability (%)	11.63 ± 0.06	17.63 ± 0.66	23.55 ± 0.52	10.45 ± 0.21
Free fat (% of total)	6.0	20.2	19.5	4.3

[1] Means ± standard error of means.

physical properties related to the reconstitutability of our own experimental goats' and cows' milk powders and the commercial powders (Table 11). All of the goats' milk powders showed good reconstitution characteristics, even commercial powder B, which had a bulk density of 48.6 g/100 cc, significantly heavier than those of the other samples, meaning that the average particle size was smaller. The solubility index was 0.2 ml or less for all powders, indicating good solubility once the powder particles had been wetted and dispersed. Sinkability was used as a measure of wettability; greatest sinkability, 23.6%, was shown by the experimental goats' powder.

Dispersibility of the experimental goats' milk powder was slightly reduced when compared to that of cows' milk powder, probably because of the higher free fat content of 19.5%. When compared to commercial powder A, commercial powder B showed higher free fat content and the sinkability was greater, probably due to the smaller particle size. Dispensibility, however, was equivalent to that of commercial powder A.

Although we did not run animal studies, we assessed the nutritive value of the goats' milk powders in terms of the essential amino acid lysine (Table 12). Processing the milk into powder did not have a significant effect on the percentage of lysine chemically available. Both the total and available lysine content of commercial powder A are lower than the contents of the other samples but this may be due to variation in the composition of the milk used. The percentage of lysine available, although lower than the value measured for the experimental powder, is about the same as that found for commercial powder B. These results, in terms of lysine, which is destroyed or rendered nutritionally unavailable by excessive heat treatment during processing or abuse during storage, show that processing fluid goats' milk into powder did not seriously impair the nutritional value. A PER test on the powder would provide confirmation of this, but at this point there is no reason to expect otherwise (Douglas, *et al.*, 1981).

Table 12. Availability of Lysine in whole goats' milk powder.

Sample	Lysine[a] (%)	Protein[b] (%)	Total lysine — g/100 g	Available lysine[c] protein —	Percent available
Fresh pasteurized	4.05 ± .06	43.22 ± .04	9.38	7.93 ± .20	84.5
Experimental powder	4.18 ± .01	45.74 ± .28	9.14	7.98 ± .13	87.3
Commercial powder A	3.89 ± .07	44.67 ± .39	8.70	6.86 ± .15	78.2
Commercial powder B	4.04 ± .01	42.69 ± .52	9.48	7.38 ± .22	77.7

[a] From amino acid analysis — duplicates or triplicates.

[b] From total nitrogen analysis — duplicates.

[c] TNBS procedure — duplicate, average error is ±3%.

Organoleptic studies

Throughout these studies we have experienced difficulties in obtaining data relative to flavor acceptability and flavor changes during storage, apparently because of the built-in bias against goats' milk by our judges. Similar problems have been encountered with milk replacers containing soy products (Holsinger, *et al.*, 1978). However, even though the hedonic rating system seemed to be undesirable for testing goats' milk products because of general dislike of the "goaty" flavor, we wanted some indication of acceptability of our processed products. Our results repeatedly showed that fresh fluid goats' milk, free of the "goaty" off-flavor, was rated equally as acceptable as cows' milk (Tables 3 and 6). In addition, "goaty" flavor is generally considered to be a defect in beverage goats' milk although it is highly desirable in some cheeses (Lowenstein, *et al.*, 1980). Measurement of flavor intensity with the five-point rating scale showed that in many cases acceptability decreased, not because of the "goaty" flavor, but because of the development of other undesirable off-flavors. Considerable work still remains to be done to solve the flavor problems of these products.

Conclusions

We have concluded from the results of these studies that: 1. the processing conditions which stabilize cows' milk concentrates during frozen storage appear to be useful for goats' milk; 2. frozen goats' milk concentrates maintained acceptable taste quality throughout the storage period; 3. additional work is needed to improve the acceptability of UHT-processed goats' milk, and; 4. that further work is required to determine the optimum heat treatment necessary to produce goats' milk powder of enhanced storage stability that can be palatable.

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Reference to a brand or firm name does not constitute endorsement by the U.S. Department of Agriculture over others of a similar nature not mentioned.

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