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ABSTRACT

This is a review of 136 publications pertaining to preparation of consumer products from goat milk. In many instances these publications do not report data from research but are descriptions of processes and practices in the manufacture of such products. A supplementary bibliography listing 183 publications is provided also. Most of these articles, or abstracts thereof, were scanned also, but their contents were not cited in the review.

This study of the literature shows that cheese is the only product made from goat milk which has been researched extensively. Few data are available on the manufacture of fluid milk products (low fat, fortified, or flavored), cultured products such as buttermilk or yogurt, frozen products such as ice cream or frozen yogurt, or butter, condensed milks, or dried milk products. While it can be claimed that data on the manufacture of these products from cow milk can be transposed to goat milk, experience has proven that such is not always possible. There is need for additional research on these products.

INTRODUCTION

World wide average milk production from goats is approximately 50 kg per doe per lactation if one-third of all goats have milk producing capability (43); they have potential for much greater productivity. The low production results from several factors, one of which is the small percentage of adult females kept for milk. Several additional causes have been discussed in other papers of this symposium. Aside from all those factors which may be associated with animal husbandry, there are two others which might be equally significant. These are a) lack of understanding of the nutrient harvest when animals are kept for milk as compared to when they are slaughtered for meat and b) inability to utilize milk in fluid form either directly as human food or for the manufacture of products exhibiting longer life or more desirable eating equalities. In this latter category, such factors as reduced bulk, increased protein concentration, reduced lactose content, and greater resistance to deteriorative effects of microbial growth are important.

It is the purpose of this paper to deal with these matters; the composition and nutritive properties of goat milk will be covered in detail in the final paper of this symposium. The relative proficiency of the goat as a producer of meat compared to its production of milk should be given serious evaluation, particularly in rural or underdeveloped areas where human needs for high quality protein cannot be provided. Admittedly an oversimplification, a comparison can be made between the utilization of that milk as human food or as food for the kids which are slaughtered for human food. In a normal lactation a doe’s milk production may range from 200 to 1200 kg (56, 127). At a 400 kg per doe per lactation production, if used for human food, milk would furnish approximately 14,800 g protein (equal to 49 g/day for a 300-day lactation), 16,800 g carbohydrate (56 g/day), and 16,400 g fat (55 g/day) (25). This is roughly the protein and energy required to raise one kid to several months of age; at this time they would begin to accept other feedstuffs to promote growth to about 32 kg by 10 mo of age. If that kid then was slaughtered, it would provide a carcass weighing about 16 kg of which about 16% is inedible (bone, etc.), 20% is fat, and 64% is lean meat. The nutrient content of the edible portion amounts to about
4500 g protein, 4000 g fat, and no carbohydrate (2). Both meat and milk would supply essential minerals and vitamins. The meat supplies significantly less nutrients and would have to be consumed in a comparatively short time. The labor in harvesting milk is much greater than that required in harvesting meat. Milk utilized directly as human food provides significantly more nutrients than that utilized for growing young animals. Why is not a greater amount so used when there is such a shortage of high quality protein? The answer has to be in the lack of knowledge and the inability to utilize milk in forms conducive to human consumption in a wide variety of circumstances. The purpose of this paper is to report research on products made from goat milk. Particular attention will be given to studies of products which have reduced bulk, increased protein concentration, reduced lactose content, and provided greater resistance to microbial deterioration.

**RAW FLUID MILK SUPPLY**

Research has been extensive relating to composition of milk produced by goats (22, 34, 37, 60, 87, 90). An excellent review of those publications was prepared by Parkash and Jenness (100). Jenness is updating that review in this symposium. The data have brought out some characteristics of the goat milk supply which have had serious impact on the kind and amount of research on goat milk products. Those characteristics of greatest importance are a) wide variations in fat and protein content of milk, b) wide variations in quantity of milk available at different seasons of the year, and c) comparatively small volume of milk in total. An additional factor having significant influence in the United States is that only a small proportion of goat milk is Grade A quality.

For its utilization in the production of consumer products, flavor is the most important quality of milk. In the manufacture of some varieties of cheese a relatively strong "goaty" flavor is preferred (7, 121), but for most products the absence of characterizing flavor is necessary. Production of "goaty flavored" milk is, to some degree, an inherited trait (121). Further investigation would be beneficial.

A number of flavors objectionable in beverage milk are associated with the lipid system. Comprehensive reports (33, 81) have shown that the proportion of short chain (4 to 10 carbon) fatty acids in goat milk is approximately double that in cow milk (97). Synthesis of fat and condition of the fat globule membrane in goat milk have been studied extensively at Pennsylvania State University following publication of research (62) which showed that goat milk did not exhibit creaming characteristics similar to cow milk because of the absence of euglobulin in materials absorbed on the fat globule. The phospholipid and cholesterol content of skim milk, derived mainly from the surface of the lactating cell, was reduced greatly by short-interval milking (102). The cholesterol content of goat milk was 406 to 484 mg/100 g fat (equivalent to 10.8 to 16.3 mg/3.5 g fat in 100 g milk) (10) whereas cow milk had 7 to 15 mg cholesterol per 100 g 3.5% fat-corrected milk (97). The hypothesis "that phosphotydlcholine synthesis regulates development of fat droplets" was advanced in 1978 (79). Perhaps the most significant finding of these studies for goat milk flavor is that during 24-h aging at 2 to 4 C there was no or little increase in phospholipid and cholesterol content of the skim portion of cow milk, whereas the skim portion of goat milk showed significant increases in those constituents under similar conditions. This may be interpreted to mean that the fat globule membrane is less stable (80) in goat milk which could result in its being more susceptible to change of flavor.

The slightly lower lactose content and slightly to considerably greater chloride content (51, 100, 128) of goat milk as compared to cow milk frequently is noted in sensory evaluation as a slightly salty flavor. This probably would not bring about adverse criticism by regular consumers if day-to-day variation were minimal. As reported by James (59) the freezing point of retail samples of goat milk varied from -.550 to −.578 C.

A study by Perez-Dominguez (104) reported that about 60% of the goat milk samples had less than 10⁶ leucocytes per milliliter and that the higher cell counts were in milk from low producers and animals in late lactation. Of these samples, only 5.2% contained mastitis pathogens. Nesbakken (95) reported that the milk from hand-milked goats averaged about one-third lower to cell count than that from herds machine milked. Current research (12,
13) is directed towards relating somatic cell numbers in goat milk to such testing procedures as the electronic somatic cell count, Wisconsin mastitis test, California mastitis test, and standard plate count. Cell counts tend to be higher in goat milk than in cow milk so that it is questionable if goat milk could meet "milk" standards (136).

BEVERAGE MILK

Relatively little has been published regarding processing and packaging goat milk as a beverage. There is need for such research because there is likely to be variation in flavor quality of raw milk, goat milk may be susceptible to off-flavor development, high somatic cell counts may be prevalent in goat milk supplies, and there seems to be wide day to day variations in goat milk composition (30, 59).

Research on goat milk products by the University of Georgia was developed around the belief that if there is to be a viable goat dairy industry, there is need for a family of products having customer appeal. In a 3-yr study of processed goat milk products, raw milk was collected for 5 days and then shipped over 1046 km in insulated, nonrefrigerated containers (76). This milk was collected from an 80-doe (5 breeds) herd managed by the Winrock International Livestock Research and Training Center at Morrillton, AR where it was cooled and held continuously at 1 to 2 C until shipped. The facilities were inspected regularly and met Grade A requirements; the product was approved for interstate milk shipment. No oxidized, rancid, salty, or offensively goaty flavored milk was detected in weekly shipments covering more than 2 yr. It was concluded (77) that if milk is collected from selected animals and properly handled and protected, off-flavors would not be a problem.

The beverage milk which has increased in consumer appeal in the United States in recent years is low fat, protein fortified milk. It was decided that goat milk processed for beverage usage would be of this type. Processing this product would permit accumulation of fat for ice cream or other high fat products. It provided a protein-enriched beverage of standardized composition, uniform from day to day. The product was pasteurized and homogenized in the same way that cow milk is processed to make it safe (136) and to add significantly to its shelf life— in Georgia milk carries a 10 day last-sale date. The experience of Malta (17) confirmed the necessity for pasteurizing goat milk as a public health measure; a case of toxoplasmosis in an infant has been traced to consumption of raw goat milk (120). No Grade A nonfat dry goat milk is available for standardization of fluid milk products, so it was necessary to concentrate skim milk by low temperature evaporative condensing before adding it back to standardize the fat content. Composition of the milk was adjusted to 2% fat and 10.5% milk solids not fat (MSNF) before it was pasteurized (HTST), homogenized, and packaged in 946 ml containers. The milk was fortified with Vitamins A and D as required by law.

Research on commercial sterilization and aseptic packaging of goat milk to provide a limited supply during the season of low production will be undertaken. Some factors influencing heat stability of goat milk have been studied (47, 71, 72). Burton (24) reported that goats milk heated to 94 to 120 C underwent the same color changes as cow milk, i.e., whitening followed by browning. Until such time as goat breeding habits can be altered to provide a uniform supply of milk throughout winter months, sterilization and storage may be the only procedure by which fluid milk can be made available for consumption in winter.

YOGURT AND OTHER FERMENTED MILKS

It would be logical to believe that yogurt and other fermented milks have been made from goat milk for centuries; published reports of research on the subject are relatively scarce. Several articles pertaining to general procedures are available (3, 5, 38, 57, 67, 77, 78). Aggarwal (3) used goat milk containing 4.3% fat and 8.6% MSNF with incubation to the final pH in the consumer package. It was indistinguishable from cow milk yogurt made by the same procedure. Duitschaever (38) and Loewenstein et al. (77, 78) used milk with 2% fat for yogurt; and former added 4% MSNF, homogenized at 200 kg/cm², pasteurized at 80 C for 15 min, cooled to 45 C, and incubated the product in its final container. No stabilizer was included in the formulation; under those conditions the yogurt was significantly less viscous than cow milk.
yogurt made in a similar manner. Goat yogurt did not show any whey-off; consumers had no difficulty distinguishing it from cow milk yogurt but preferred its smooth body and sharp flavor. The goat yogurt showed more rapid development of lactic acid than cow yogurt (38).

Goat yogurt produced at the University of Georgia (5, 77, 78) was processed in a different manner. Both Swiss and sundae-style products were made. Milk standardized to 2% fat and 10.5% MSNF, pasteurized, and homogenized at the time and beverage milk was processed was used in yogurt manufacture. This was held in bulk 24 to 48 h; in the yogurt making process it was stabilized with 250 bloom gelatin in sufficient quantity (.25 to .7%) to give the desired viscosity, then repasteurized (86 C for 30 min), cooled to 42 C, inoculated, and incubated in the processing vat. When the desired acidity was developed, the product was cooled further to 22 C, fruit puree was added and mixed if desired, and the finished product was packaged and stored at 5 C. The final viscosity was attained after the product was chilled to holding temperature. In the manufacture of sundae-style yogurt, the usual practice was modified to the extent that instead of adding a fruit puree to the cultured milk, a preserved fruit flavoring was injected into the package just before the unflavored yogurt was added with a two stage mechanical filler (5). This research confirmed the findings of Duitschaever (38) that at the same composition goat yogurt was significantly less viscous than cow yogurt; this was of greater importance in sundae-style than in Swiss-style. In a comparison of the two styles of product, consumers preferred sundae-style about 4 to 1 (5). To produce the most acceptable product with the least amount of stabilizer, the MSNF content of the original milk base was increased to 12.0%. Sundae-style yogurt made in this manner had the highest acceptance rating in consumer evaluations (77).

The amino acid profile of goat yogurt was studied by Nazarova (94), Rasic et al. (118), and Duitschaever (38), who concluded that it did not differ significantly from cow milk yogurt. Hadland and Hoffman (55) found that high-temperature long-time pasteurization (80 C for 10 to 45 min), greater concentration of solids (to 13.5% TS), and homogenization (150 to 200 kg/cm² at 60 to 70 C) were helpful in increasing the viscosity of fermented goat milks. Several research reports (1, 38, 131) showed more rapid acid development in goat milk cultured with yogurt organisms than in cow milk under the same conditions. Prodanski (116) reported that acidity developed in the milk of different mammals at the time of coagulation was dependent on temperature of pasteurization and time of holding. Gorner et al. (54) reported on the volatile, flavor producing compounds formed in goat milk cultured with yogurt organisms.

**FROZEN YOGURT**

Extensive search of the literature failed to show any research with frozen yogurt made from goat milk except at the University of Georgia (18, 77, 78). Frozen yogurt is relatively new in the family of dairy foods and is made in two forms, soft-serve and hard frozen. Distributors frequently use the same mix in making both types. Frozen goat yogurt can have the same composition as frozen cow yogurt.

A high quality formulation acceptable to the consumer was 2.0% milk fat, 10.0% MSNF, 10% sucrose, 10% corn syrup solids (36 dextrose equivalent), and .5% soft-serve stabilizer. Since no nonfat dry goat milk is available, concentrated MSNF must be made; condensed skim is prepared most easily. It can be stored in frozen form if necessary. Any combination can be used of fresh or frozen goat milk, cream, skim, condensed skim, and yogurt culture together with the sweeteners and stabilizer which gives the desired composition. The mix is prepared as two combinations of ingredients; yogurt cultures show minimum activity in a milk base with high sweetener content. Sufficient fluid milk, skim, and/or water (if calculated as part of the formula) to permit complete dispersion of the sweetener and stabilizer is withheld from the yogurt base and processed as a separate entity. The remainder of the fluid milk, skim, cream, and concentrated milk are combined and pasteurized at 82 to 84 C for 30 min (if fat containing ingredients were not homogenized previously, they are preheated to 65 to 70 C, homogenized at 200 kg/cm², then completely pasteurized). The mix is cooled to 41 to 42 C, inoculated with 4% active yogurt culture (culture included as part of ingredients in calculations of formula), and incubated at 42...
C to a titratable acidity of 1%. During incubation, fluid milk, sweetener, and stabilizer withheld previously (with care to get stabilizer completely dispersed) are combined and pasteurized at 80°C for 30 min, and cooled to 40 to 42°C. After pasteurization and incubation are complete, the two fluids are combined, cooled to <5°C, and packaged. Best results will be obtained if mix is held 24 h before freezing as either soft-serve or hard frozen yogurt. Flavoring materials usually are added at the freezer; frozen yogurt should be drawn from the freezer at about 50% overrun with temperature of -5 to -6°C. Packaged mix may be frozen quiescently for long storage and/or distribution. The packaged mix will have a usable shelf life of 30 days if stored at 2 to 5°C and much longer if held at -25°C or below.

**ICE CREAM**

No references to research in ice cream made from goat milk have been found excepting those at the University of Georgia (76, 77, 78), and that work only involved application of general knowledge of ice cream making to utilizing goat milk and derivatives thereof as fat and MSNF in the formulations desired. Because goat milk products are significantly more expensive than comparable cow milk products, goat ice cream would have to be of premium quality to attract consumers. This decision was corroborated by experience. With the two major items of sale (milk and yogurt) being low-fat high-protein type products, excess fat was accumulated. Premium ice cream contains a high fat-to-MSNF ratio, thereby providing a market for the excess fat. It requires the manufacture of a specific mix formulation for each flavor produced.

The three formulations made, for the three flavors of ice cream, were:

1. French vanilla mix\(^2\): 14.6% fat (.6% cocoa fat), 9% MSNF, 18% sweetener (14% sucrose, 6% 36 DE corn syrup solids), 3% medium fat cocoa (or finely ground carob powder), and .22% stabilizer-emulsifier.

2. Chocolate (or carob) mix: 14.6% fat (.6% cocoa fat), 9% MSNF, 20% sweetener (14% sucrose, 6% 36 DE corn syrup solids), 3% medium fat cocoa (or finely ground carob powder), and .22% stabilizer-emulsifier.

3. Premium white mix\(^3\): 15% fat, 10% MSNF, 18% sweetener (12% sucrose, 6% 36 DE corn syrup solids), and .25% stabilizer-emulsifier.

Fresh cream, frozen cream, and fresh milk were used as sources of fat and MSNF; concentrated skim was the only MSNF concentrate available. All were derived from raw goat milk received at weekly intervals; nearly all were pasteurized prior to incorporation in ice cream mix because of the time needed to accumulate an adequate volume for processing.

Processing of the mix and production of the frozen ice cream were accomplished in the usual manner: vat pasteurization at 72°C for 20 min, homogenization at 175 to 180 kg/cm\(^2\) (single stage), cooling to <5°C, holding for 24 h at <5°C, freezing to 75 to 80% overrun at -5°C, packaging (round pint containers), hardening, and storing at -18 to -20°C. Three flavors were made—French vanilla, chocolate almond (broken pieces of almonds added to chocolate ice cream as it passed from freezer), and strawberry (3 to 1 cold pack sliced berries added to frozen ice cream). All were more highly flavored than competitive ice cream products.

Barnard and Ace (16) have published instructions for making homemade ice cream (custard type) from goat milk.

**CHEESE**

Cheese may have been one of the first manufactured foods consumed by man. History records its usage more than 4000 yr ago (4, 26, 67, 96). No one really knows when the first goat milk was made into cheese; that detail is academic. That in 1979 a large portion of the world’s production of goat milk is made into cheese is of great practical importance (27, 35, 73, 91).

Varieties

The manufacture of goat cheese should be categorized most accurately as a “cottage industry” rather than a commercial industry. This has led to the development of numerous

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\(^2\)Fortified vanilla extract was added during freezing.

\(^3\)Used when bulky flavors such as strawberries are added at freezer.
varieties of cheese, many named for the town or locality in which produced. Agriculture Handbook No. 54 (4) describes over 400 varieties and list over 800 names of cheeses; a great number of these are, or can be, made from goat milk or from combinations of goat milk with milk from the cow, ewe, or buffalo. The following are representative of the numerous references to specific varieties of cheese made from goat milk: Portman et al. (115) Sainte-Maure; Cargouet (27) and Cargouet and Sorin (28) Sainte-Maure, Chabichou, Pyramide, Sellesur-Cher, Charente-Poitau; Rakshy and Hassan (117) Domiati type or Feta; Elias (40) Fr. Pat. 2,112,160, no name; Efthymiou (39) US Pat. 3,843,801; Bender-Vaillant (20) Sainte-Maure; Bottazzi (21) Pecorino romano, Caprini or Robiolini freschi; Lame and Hekmati (70) Khikki; Laiterie Cooperative de Saint-Saviol (69) Fr. Pat. 2, 278, 250, Saint-Saviol; Delforno (32) Caprino di Rimella, Orserva, Paglierina, Raschiera; Strauss Dairies, Israel (8) Eezit; Dozet (35) Kajmak; and Fredriksen and Steinsholt (48) processed goat milk cheese. In a number of these publications basic processing procedures are given; in a few the general composition of the product is shown. Less than half of the varieties listed in the articles cited are among the 800 named in Agriculture Handbook No. 54 (4).

Diversity

The large number of varieties of cheese made from goat milk have resulted in great diversity in the nature of the products. The milk from which it is made significantly influences the finished cheese. As previously mentioned, either pure goat milk or goat milk combined with that from other mammals may be used (32, 67, 70). Some varieties of farm cheese made from the milk of a few animals (16, 61, 91, 129) lack uniformity; other farm cheese varieties, where the herd is large or milk is collected from several farms (20, 61), may be quite consistent in composition but distinctive in flavor. Ricordeau and Mocquot (119) have pointed out how seasonal variations in the composition of goat milk are reflected in the yield of the cheese. Portmann et al. (114) and Steinsholt (130) showed that making cheese from partly skimmed or fat enriched milk resulted in significant differences in yield of cheese. A number of research reports (14, 15, 50) have shown that the flavor quality of the milk is reflected in flavor development in cheese; when a strong flavored milk was processed, it gave stronger flavored cheese. The intensity of the goaty flavor was correlated highly with the free fatty acid content (14, 15); some consumers preferred such flavor, but others preferred a milder flavor (7, 50).

There is evidence that the production of milk with strong "goaty" flavor is an inherited trait; where desired, certain breeding patterns should be followed (7).

The great number of goat cheese manufacturers supplying many local markets with a variety of types and ages of product have developed numerous processing and aging procedures. While some goat cheese is made from pasteurized milk (27, 40) most reports of processing do not include pasteurization (21, 39, 61, 91). The consumption of unpasteurized goat cheese has been identified as the cause of epidemics of Brucellosis (41, 132). Manufacturing techniques include wide variations in amount and species of organism used in culturing (39, 40, 52), incubation procedures (50, 91), and forming or pressing techniques (27, 69). Variations in aging time and conditions play a most important part in determining the flavor, body, and texture of cheese (21, 32, 61, 70, 91).

Goat cheeses, like all other cheeses, utilize a variety of microorganisms in manufacture and aging to produce the final flavor, body, and texture qualities. In many instances cheese is made without culture, relying on the natural flora to develop the acid needed to cause protein coagulation (52, 67). Some form of enzyme generally is used to cause casein precipitation (67, 91). Much of the varietal differences between cheeses is due to the physical and chemical changes during ripening or aging. Such changes (53, 58, 70) result from activity of microflora and enzyme systems in the cheese; for many varieties the nature of those systems is the result of cultures, chemicals, or flavor ingredients added to the curd prior to or at the early stages of ripening. Typical examples of such additives are cultures of blue-green or white mold of the Penicillium genera (species roqueforti or camemberti) or Brevibacterium linens; salt is incorporated in many varieties of cheese for the effect it may have on microflora activity as well as its flavor; and some herbs or
spices are added to a few varieties to produce specific flavor effects (4, 21, 48, 67).

In discussing the numerous varieties of cheese made from goat milk, mention must be made of whey cheese. This type of product is especially popular in Norway (91) where the caramelized lactose in concentrated whey is combined with fat and whey proteins to make Gjetost cheese. Mysost, Gudbrandsdalsost, and Primost are made by the same basic process but by changing the blend of ingredients, including some cow milk products (67, 96). Ricotta is a cheese which may be made from goat cheese whey; cheeses of a similar nature have other names when made in other countries (4, 67). Broccio is a whey cheese made by combining goat milk with the whey from goat cheese (91).

Composition

While several of the articles relating to the manufacture of goat cheese do give definitive data on the composition of the final product, most do not. The best source of information on composition of goat cheese in general is Agriculture Handbook No. 54 (4), but, as mentioned, many of the local varieties are not listed in it. With the wide variation in the composition of milk, modifications in manufacturing procedures, and multitude of aging time and conditions, it is expected that goat cheese would have a wide range in composition. Portman and Pierre (111) reported that the pH at the time of molding Saint-Maure type cheese had a significant effect on composition of the finished product; the dry matter and calcium contents were reduced as the pH was lowered from 6.6 to 4.6.

Characteristics in Common

While there are wide variations in the flavor, body, texture, and specific nutritional qualities of goat cheeses, they have characteristics in common. Production is usually seasonal since a large volume of milk is available only 4 to 6 mo of the year (67). The varieties consumed without aging are available in limited supply during months of low milk production. Therefore, the manufacture of varieties which are aged, such as Feta, Romano, Domiati, etc. serve several important functions. They please the palate of those who prefer flavorful cheese, and they furnish a supply of milk based products even during the nonproductive season of the year. Most of the goat cheeses are made by procedures involving slow coagulation, curd remaining with whey until dipped into molds, and drying of the cheeses before ripening (91). Goat cheeses are, as are all cheeses, highly nutritious. They contain a high ratio of protein to calories (34) and have a liberal content of many minerals. Their content of fat soluble vitamins, proportional to their fat content, may be high or low. Many varieties of cheese contain higher concentrations of some water soluble vitamins, such as thiamin, riboflavin, and niacin, than does the milk from which cheese is made (2).

Problem Areas Currently Being Researched

Several current problem areas related to the manufacture of goat cheese have received special attention. A problem of great concern studied extensively in recent years is that of seasonal milk supply. The impact of 75% of the cheese milk being collected from April to September was pointed out by Saurais (125). Several approaches have been taken to solving the problem. The necessity for developing programs to give more uniform production all seasons was noted by Rulliere (123). What probably should constitute the main thrust of such a program, the synchronization of estrus by the progestogen sponge technique and the use of artificial insemination, was advocated by Fataux (44). Relief from the problem through such a program probably will be a long time developing.

In the meantime, goat cheese makers are experimenting with other ideas. One is freezing curd and holding it in frozen storage. Portmann et al. (115) experimented with curd from both raw and heat treated milk stored at -20 or -25 C for 3, 5, or 8.5 mo. Saint-Maure cheese was made from the stored curd and ripened for 3 wk. After 3-mo storage, the curd produced cheese with 90% scoring “good” or “intermediate”. With the storage period extended, the proportion of “poor” cheese increased to 25 and 40%. Subsequent to the original tests a commercial lot of curd was prepared, wrapped in aluminum foil, and stored 4 to 6 mo at -18 C. All the cheese made from it was assessed “good”. Following their initial success, Portmann et al. (113) added 1.6% salt to the curd.
before freezing and storing it; cheese made from this curd generally was less desirable in flavor than that made from fresh curd. Portmann later (110) made similar tests with several qualities of salt as well as ascorbic acid and butylated hydroxyanisole as additives to the curd being stored. The quality of salt was of no importance; the addition of the antioxidants produced no conclusive results. Tiersonnier (134) and Saurais (125) advised the frozen storage of curd as a means of combating the problem of seasonal milk supply.

The process of ultrafiltration developed in the 1960's (42) was adapted for treatment of cheese whey (45, 83, 88, 89) as a means of recovering valuable constituents and reducing the whey disposal problem. Maubois and Mocquot, with the collaboration of others (85), described the application of ultrafiltration to the production of a "precheese" fraction from goat milk which subsequently was made into cheese. The new technique resulted in increased yields without sacrifice in quality and provided other advantages. A French patent was issued from this research. Later reports (65, 66, 86) showed how the preparation of a milk protein concentrate by ultrafiltration was being utilized in the manufacture of Camembert, Saint-Paulin, Mozzarella, and cream type cheeses. Cargouet and Sorin (28) studied the manufacture of Sainte-Maure and Chabichou cheese by ultrafiltration. Dariani (31) has studied the manufacture of a cream cheese type product using ultrafiltration. One of the major advantages of this technique, as pointed out in these reports, was the possibility of holding the "precheese" material in frozen storage for later use in cheese manufacture. Such a procedure also has been used to prepare a spray dried precheese material which is reconstituted and made into cheese at a later date (66, 106). Thus, the application of ultrafiltration to cheesemaking procedures has made it possible to manufacture goat milk cheese even when the fluid milk supply is diminished.

Another problem in the manufacture of goat cheese which has received attention is the mixing of goat milk with other milks and identification of products made from mixtures. Mixing milks seems to be fairly common as a means of extending the supply of goat milk and of reducing the cost of the finished product. Properly labeled, such cheese undoubtedly has a place in the market; but if marketed as a pure goat milk product, such cheese could cause difficulties in digestion for some individuals. Maree (82) and Ruehl (122) have pointed out that a significant proportion of the human population exhibits distinct allergy to cow milk protein, although symptoms attributed to such an allergy frequently are not true protein antigenicity. It is not important to this symposium whether the allergic response is to the casein or a whey protein as Saperstein (124) has discussed. Proteins in goat milk differ from those in cow milk both quantitatively and qualitatively (29, 68, 74, 82, 92, 103). The extent to which goat milk may be used to alleviate allergy from cow milk protein has been questioned (82, 124) even though it is used widely for that purpose. A number of studies (11, 23, 46, 49, 105, 108, 109, 112) developed procedures for detecting cow milk protein in goat milk or goat cheese by polyacrylamide gel electrophoresis; adulteration of 5 to 10% could be detected. While this process does not give complete protection to those individuals who cannot tolerate cow milk protein, it does provide regulatory officials a tool with which to insure more accurate labeling of cheese.

French Patent No. 2,290,847 (135), detailing a procedure for continuous manufacture of curd for cheesemaking, has been granted.

Other Manufactured Products

No mention has been made of butter, condensed, evaporated, or dried milks from goat milk. While we are aware of the capability to make such products, our literature search failed to find any research on them. We have not conducted any tests on the products at the University of Georgia.
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