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Goat Milk: Composition & Processing Technology

This bulletin includes technical information based on latest developments on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information in different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue is **"Goat Milk: Composition & Technology of Processing"** It may be understood that the information given here is by no means complete.

In this issue:

INTRODUCTION

The goat is one of the most versatile domestic animals in adaptation to arid and humid, tropical and cold, desert and mountain conditions providing people with many important products, such as meat, milk, cashmere, mohair, skins, leather, draught and pack power, and manure for crops and gardens.

The growing interest in goat milk is not only focused on the sustenance of the poor and rural people with small land holdings and to educate them of the value and acceptability of goat milk, but also as an important "super" dairy food product with special medical, nutritional, biological, and immunological characteristics.

Physical Properties

Properties	Goat	Cow
Specific Gravity (Density)	1.029-1.039	1.023-1.039
Viscosity (cP)	2.12	2.0
Surface Tension	52.0	42.3-52.1
Conductivity (Ω^{-1}/cm)	0.0043-0.0139	0.0040-0.0055
Refractive index	1.450±0.39	1.451±0.35
Freezing point (-°C)	0.540-0.573	0.530-0.570
Acidity (LA %)	0.14-0.23	0.15-0.18
pH	6.50-6.80	6.65-6.71

Composition

Although there are certain species-specific differences in composition of milk, the basic nutrient composition of goat milk is similar to that of cow milk. Like in the case of cow milk, the composition of goat milk varies with diet, breed, animals within breed, parity, environmental conditions, feeding and management conditions, season, locality, and stage of lactation.

Caprine milk, on the average, contains 12.2% total solids, consisting of 3.8% fat, 3.5% protein, 4.1% lactose, and 0.8% ash (Table 1), indicating that it has more fat, protein, and ash, and less lactose than cow milk. Goat milk contains slightly less total casein, but higher non-protein nitrogen than the cow counterpart.

Table 1. Basic composition of goat, cow (mean values per 100 g).

Constituents	Goat	Cow
Fat	3.8	3.6
Protein	3.5	3.3
Lactose	4.1	4.6
Ash	0.8	0.7
Total solids	12.2	12.3

1. Lipids

One of the significant differences between goat and cow milk is found in the physicochemical structure and composition of milk fats. The average size of goat milk fat

globules is about 3.5 micrometers (µm) as compared to 4.5 µm for cow milk fat. Average diameters of fat globules for goat, cow, buffalo, and sheep milks were reported to be 3.49, 4.55, 5.92, and 3.30 µm, respectively. Smaller fat globules make a better dispersion and more homogeneous mixture of fat in goat milk, which would provide lipases with a greater surface area of fat for enhanced digestive action. That's why goat milk is considered as "self-homogenized" milk. In respect to free lipids, goat milk has higher values than that of cow milk.

This smaller physical size of goat milk fat globules appears to be associated with poor creaming ability of goat milk. Goat milk contains 97–99% of free lipids and 1–3% bound lipids of total milk fat. The comparison of fatty acid composition of total lipids showed that goat milk fat has significantly higher levels of short and medium chain length fatty acids (MCT) (C4:0-C14:0) than cow and human milks (Table 2). Goat milk has almost twice higher amounts of caproic (C6:0), caprylic (C8:0), and capric (C10:0) acids than cow milk, which are highly correlated to "goaty" flavour. Goat milk has a unique characteristic in the lauric:capric fatty acid (12:10) ratio, where it has a significantly lower ratio than cow milk (0.46 versus 1.16). The FFA fraction in goat milk has been related to "goaty" flavor intensity in the milk. Free fatty acid (FFA) content of goat milk is 3.11 µeq/ml compared with cow milk (3.0 µeq/ml) and buffalo milk (3.4 µeq/ml). Lipolysis in goat milk increases during storage at room temperature for 4 and 12 h. Goat milk has a higher sensitivity to

spontaneous lipolysis than cow milk due to the difference in lipase distribution.

Table 2. Fatty acid composition of total lipid of goat and cow milk

Fatty acid	**Total lipid (g/100 g fat)**	
	Goat	**Cow**
Butric acid C4:0	2.6	3.3
Caproic acid C6:0	**2.9**	**1.6**
Caprylic acid C8:0	**2.7**	**1.3**
Capric Acid C10:0	**8.4**	**3.0**
Caproleic acid C10:1	Tr	Tr
Lauric acid C12:0	3.3	3.1
Dodeconic acid C12:1	Tr	Tr
Tridecylic acid C13:0	Tr	Tr
2-Tridecenoic acid C13:1	Tr	Tr
Myristic acid C14:0	10.3	9.5
Myristoleic acid C14:1	Tr	Tr
Pentadecanoic acid C15:0	Tr	Tr
C15:1	Tr	Tr
Palmitic acid C16:0	24.6	26.5
Palmitoleic C16:1	2.2	2.3
Heptadecanoic acid C17:0	Tr	Tr
Stearic C18:0	12.5	14.6
Oleic C18:1	28.5	29.8
Linoleic C18:2	2.2	2.5
Linolenic C18:3	Tr	1.8
Tr: traces		

2. Carbohydrates

The major carbohydrate of goat milk is lactose, which is about 0.2–0.5% less than that of cow milk. Other carbohydrates found in goat milk are oligosaccharides, glycopeptides, glycoproteins and nucleotides in small amounts. Goat milk is significantly rich in lactose-derived oligosaccharides compared to cow milk. Milk oligosaccharides are thought to be beneficial to human nutrition because of their prebiotic and anti-infective properties.

3. Proteins

There are five principle proteins in goat milk: β-lactoglobulin (β-Lg), α-lactalbumin (α-La), κ-casein (κ-CN), β-casein (β-CN), and αs2-casein (αs_2-CN) (Table 3). Electrophoretic mobility under standard conditions shows that β-casein is the major component of the casein fraction in goat milk, whereas αs_1-casein is the major casein in cow milk. Total casein content of goat milk is slightly lower than that of cow milk. The percentages of αs_1- and αs_2-caseins in goat milk are markedly different from those in cow milk, where goat ilk has much lower αs1 and higher αs_2 than cow milk. However, goat milk showed considerable variations in its αs_1-casein content ranging from 2.7 g/l to only 0.12 g/l. β-Casein is the most abundant protein in goat and human milks, while αs_1 is the major protein in cow milk. Levels of αs-casein are minimal in human milk.

Table 3. The percent composition of different protein fractions in goat and cow milks are summarized below.

Proteins	Goat	Cow
Proteins (%)	3.5	3.3
Total casein (g/100ml)	2.11	2.70
αs1 (% of total casein)	5.6	38.0
αs_2 (% of total casein)	19.2	12.0
β (% of total casein)	54.8	36.0
κ (% of total casein)	20.4	14.0
Whey protein (%) (albumin and	0.6	0.6
Non-protein N (%)	0.4	0.2
Lactoferrin (µg/ml)	20-200	20-200
Transferrin (µg/ml)	20-200	20-200
Prolactin (µg/ml)	44	50
Folate-binding protein (µg/ml)	12	8
Immunoglobulin		
IgA (milk: µg/ml)	30-80	140
IgA (colostrum: mg/ml)	0.9-2.4	3.9
IgM (milk: µg/ml)	10-40	50
IgM (colostrum: mg/ml)	1.6-5.2	4.2
IgG (milk: µg/ml)	100-400	590
IgG (colostrum: mg/ml)	50-60	47.6
Lysozyme (µg/100 ml)	25	10-35
Ribonuclease (µg/100 ml)	425	1000-2000
Xanthine oxidase (µl O_2/h/ml)	19-113	120

Table 4. Amino acid composition of goats and cow milk (mg/100g)

Amino acid	Goat	Cow
Tryptophan	44	46
Threonine	163	148
Isoleucine	207	198
Leucine	314	321
Lysine	290	260
Methionine	80	82
Cystine	46	30
Phenylalanine	155	158
Tyrosine	179	158
Valine	240	220
Arginine	119	119
Histidine	89	89
Alanine	118	113
Aspartic acid	210	249
Glutamic acid	626	687
Glycine	50	69
Proline	368	318
Serine	181	178

4. Enzymes

Distribution of enzymes in goat milk is quite different from that in cow milk. Alkaline phosphatase content in goat milk ranged from 11 to 13 mg/l, and the inactivation of this enzyme was reportedly at around 45°C by some authors, implying that the alkaline phosphatase test may

not be effective for pasteurization of goat milk. Acid phosphatases (AP) also have been determined in goat and cow milks, where the activity levels of the enzyme in goat and cow milks were 0.136 and 0.076 units/g protein, respectively. Xanthine oxidase activity of goat milk is less than 10% of that of cow milk. Xanthine oxidase has been associated with the control of various redox reactions in the cell and plays an important role in Fe absorption, facilitating the oxidation and combination of Fe with transferrin, and coupling antibacterial effect via the lactoperoxide system. Goat milk contains less lipase than cow milk. Lipase is a lipoprotein with technical applications due to its involvement in spontaneous and induced lipolysis. In contrast to that in cow milk, lipase activity in goat milk is significantly correlated with spontaneous lipolysis, possibly because of its specific lipolytic system. Lipases play a major role in flavour development in milk and dairy products during milk processing and storage. Goat milk exhibited significantly lower lipoprotein lipase activity in fresh milk cooled to 4°C than cow counterparts.

5. Minerals & Vitamins

Goat milk has higher calcium, phosphorus, potassium, magnesium, and chlorine, and lower sodium and sulphur contents than cow milk.

Table 5. Mineral and vitamin contents of goat milk as compared with of cow Milk (in 100g)

Constituents	Goat	Cow
Minerals		
Ca (mg)	134	122
P (mg)	121	119
Mg (mg)	16	12
K (mg)	181	152
Na (mg)	41	58
Cl (mg)	150	100
S (mg)	2.89	-
Fe (mg)	0.07	0.08
Cu (mg)	0.05	0.06
Mn (mg)	0.032	0.02
Zn (mg)	0.56	0.53
I (mg)	0.022	0.021
Se (µg)	1.33	0.96
Vitamins		
Vitamin A (IU)	185	126
Carotene (µg)	-	16.0
Vitamin D (IU)	2.3	2.0
Thiamine (mg)	0.068	0.045
Riboflavin (mg)	0.21	0.16
Niacin (mg)	0.27	0.08
Pantothenic acid	0.31	0.32
Vitamin B6 (mg)	0.046	0.042
Folic acid (µg)	1.0	5.0
Biotin (µg)	1.5	2.0
Vitamin B12 (µg)	0.065	0.357
Vitamin C (mg)	1.29	0.94

Goat milk has higher amounts of vitamin A than cow milk. Caprine milk is whiter than bovine milk because goats convert all β-carotene into vitamin A in the milk. Goat milk, however, has a significant drawback in deficiencies of folic acid and vitamin B12 as compared to cow milk. Cow milk has 5 times more folate and vitamin B12 than goat milk, where folate is necessary for the synthesis of haemoglobin. Vitamin B12 deficiency has been reportedly implicated in "goat milk anemia," which is a megaloblastic anemia in infants. However, the major cause of the anemia has been shown to be attributable to the folate deficiency in goat milk. Both goat and cow milks are equally deficient in pyridoxine (B6), vitamin C, and vitamin D, where these vitamins must be supplemented from other food sources.

Flavor of Goat Milk

An important feature of goat milk is the well-known goat flavour (discussed in Sec Lipids), often reported as "goaty," which is not accepted by some consumers. The sensory profile and off-flavors in particular of raw milk are associated with the following factors, which must be controlled:

i. Breed and other genetic factors.
ii. Physiological factors (stage of lactation, udder health).
iii. Feeding systems (pasture or indoor feeding, preservation method of feed, botanical composition of pasture, and type of diet) can affect the oxidative

stability of milk and consequently the development of off-flavors.

iv. Environmental conditions because volatile compounds may be transferred into milk.

v. Induced or spontaneous lipolysis in raw milk, which is the hydrolytic rancidity of raw milk,that is hydrolysis of triacylglycerides catalyzed mainly by indigenous milk lipoprotein lipase (LPL). Lipolysis, expressed by a high level of free fatty acids (FFA) can be induced by particular treatments (pumping, agitation, mixing with air, foaming, milking systems, temperature changes), which disrupt the integrity of the milk fat globule membrane. On the other hand, spontaneous lipolysis occurs in some individual milk cooled soon after milking.

vi. Microbial quality of raw milk especially the counts of psychrotrophs that dominate raw milk kept at low temperatures for >2 days; off-flavors result often from the activity of their proteolytic and lipolytic enzymes.

vii. Similarly, high SCC is often correlated with enhanced proteolytic activity induced by plasmin or other proteinases.

Off-flavors in goat milk can be avoided by controlling the above-mentioned factors. Especially FAA must be low, since goat flavor is attributed to an excessive FFA content, in particular medium- and short-chain ones. Capric, caproic, and caprylic acids make up 20 to 25% of all FFA in goat milk, giving thus “goaty” and rancid taste to goat milk. Chilliard et al. (2003) ascribes the development of goat flavor to the release of branched medium-chain fatty acids and the development of rancidity to excessive release

of butyric acid. They report that goat flavor in cold, stored fresh milk appearing at low lipolysis levels comes from C6:0 to C9:0 FFA and more specifically from volatile branched-chain C9 and C10 as 4-methyl and 4-ethyl-C8, which are 0.3–0.4 g per kg of fat in goat milk. Goat milk fat composition and its lipolytic system are the responsible factors. The latter is practically the activity of lipoprotein lipase (LPL), which is lower compared to that in cow's milk. However, spontaneous lipolysis is correlated well with LPL activity in goat milk, apparently because a large proportion of it is bound to cream, in contrast to LPL of bovine milk bound to casein micelles. The membrane is more fragile in goat milk fat than in cow milk fat and easily broken during improper handling, insufficient cooling and repeated rewarming, when enzymes are liberated and cause lipolysis, releasing FFA.

Somatic Cell Count

The milk somatic cell count (SCC) is considered as a mastitis index and therefore legislation limits are set. According to EU Regulations (European Union, 2006), the limit for the geometric average for cow milk is 400 000 cells/ml over a period of three months; no figures are given for small ruminants' milk. In the Grade "A" Pasteurized Milk Ordinance (US Food and Drug Administration, 2013), cow milk from an individual producer's milk should not exceed 750000/ml. However, the limit for goat milk is

higher, set at 1500000/ml. This differentiation is necessary due to particularities of SCC in goat milk. Total SCC does not correlate with the leucocyte count. In the milk of healthy goats it is higher, especially in the late stages of lactation, ranging from approximately 750000 to 5.4 million cells/ml, and neutrophils are the main cell type contrast to macrophages, which are the major cell type in cow and sheep milk. The high SCC is a result of the apocrine secretory process that results in a high number of round cytoplasmic particles and epithelial cells in the milk of small ruminants. This phenomenon is more intense in the goat milk. Moreover, other factors apart from mastitis, such as lactation stage, breeds, parity, way of milking, and goat breed, influence strongly the goat milk SCC.

Alcohol stability of goat milk

The alcohol test is a practical means of determining the susceptibility of bovine milk to coagulation by heat. Goat's milk is much less stable compared with bovine milk in terms of heat and alcohol stability due to the differences in chemical composition and casein profiles. In general the ethanol stability of cow & Buffalo milk is 70-80% and 60-72% (measured as concentration of ethyl alcohol in an aqueous solution) respectively at its natural pH. Literature suggest that the alcohol precipitation for dairy goat milk

may have to be tested with ethanol concentration less than 45% for the determination of freshness and heat-stability.

Heat stability of goat milk

Heat stability of milk is greatly important for processing and production of dairy foods, especially in goat milk product manufacture. Goat milk has a great sensitivity toward heat treatment, whereby it is usually unable to withstand UHT treatment. The problem of stability in high temperature treated goat milk was not resolved due to rapid destabilization and flavor alteration of UHT processed fluid goat milk. Goat milk is considerably less stable to heat than bovine milk. Milk pH is a very important factor for heat stability. A pronounced heat stability maximum at about pH 6.9, with low heat stability at both low and high pH. The lower heat stability of goat milk may account for the differences between micellar characteristics or salt equilibria of the two milks.

An increase in the solubilization of colloidal calcium phosphate and an increase in calcium ion activity decrease the heat stability of goat milk. The outcome of many studies is that compositional factors in respect to protein fractions and mineral balance configure heat stability. Micelle structure in goat milk differs from that of cow milk. Goat casein micelle contains more calcium, inorganic phosphorus and non-centrifugal casein, and are less heat stable. It is less hydrated and has higher average diameter

than cow milk due to more intense mineralization of the former. Also, there are differences in minerals; goat milk has more Ca, P, K, Mg, and Cl and less Na and S than cow milk. With respect to the αs1-genotype, the outcome is that it does not affect heat stability whereas pH and ionic calcium are the deciding factors.

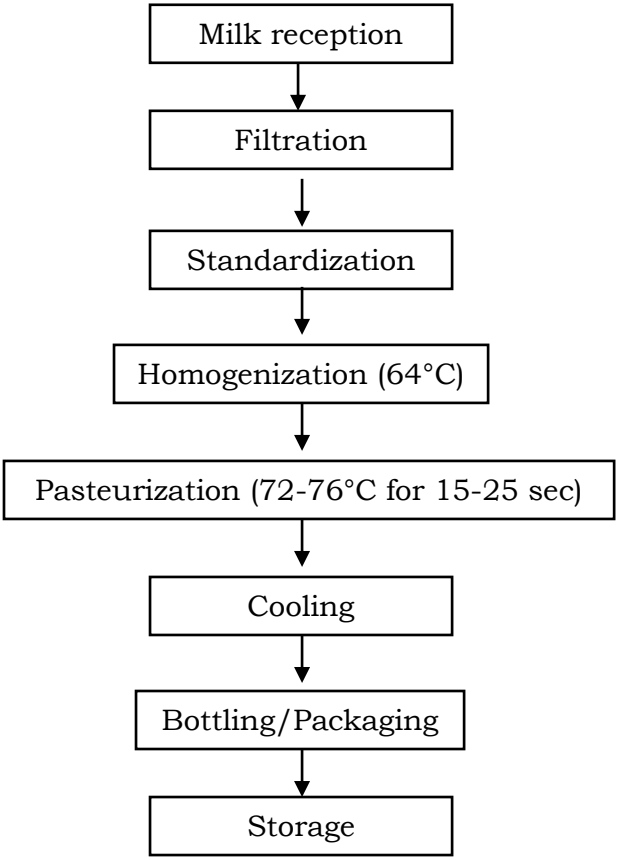
A high SCC of goat milk may impair heat stability of goat milk, because it is consistent with increased concentrations of the heat labile immunoglobulins.

Use of additives such as phosphates and trisodium citrate before heat treatment improve the heat stability of goat milk, first by increasing pH. Reduction of pH during heat treatment limits the negative charge of the micelles and increases ionic calcium concentration. Depending on the additive, the calcium partition in milk changes. Trisodium citrate solubilizes both colloidal calcium phosphate and calcium of phosphoseryl residues, increasing thus the charge density and the number of small casein micelles. On the other hand, phosphate binds ionic calcium, which may induce calcium phosphate precipitation on to the goat casein micelle and decrease of the charge, resulting in destabilization.

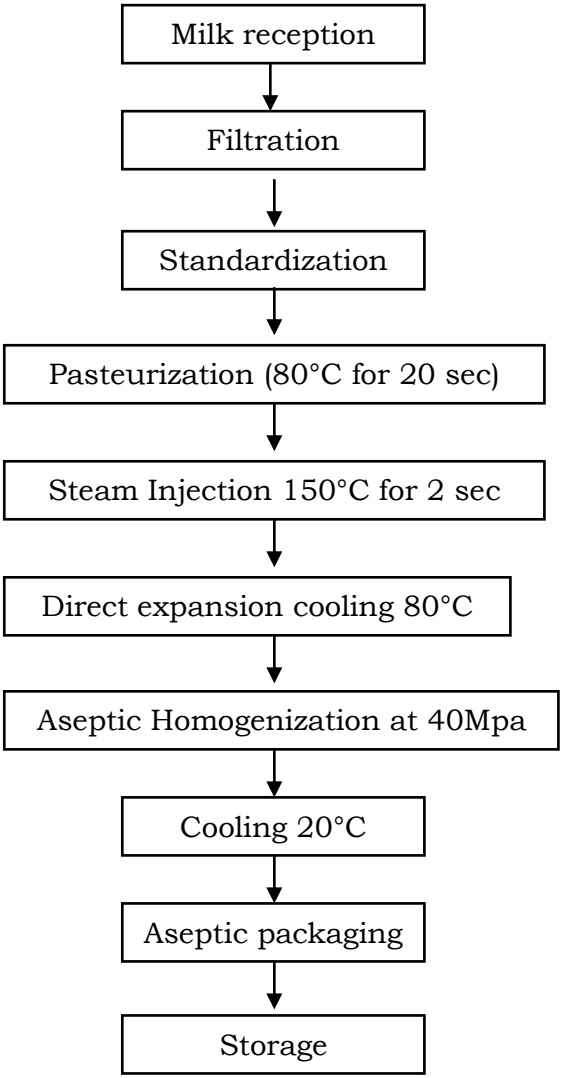
Heat stability of goat milk treated at 140°C has been found 0-2 min at pH<6.9, while cow milk with stands 140°C for 12-22 min at natural pH. Goat milk is characterized by lower colloidal stability than bovine milk, which results in low heat stability at high temperature and more deposit formation during pasteurization.

Goat milk: Processing Technology

1. Pasteurized fluid Goat Milk



2. UHT fluid Goat Milk



Shelf life

Goats' milk of excellent flavor, bacteriological quality, and storage stability could be produced by pasteurizing fresh milk no more than 1 or 2 d old. Holding of the chilled raw milk for several days before pasteurization, a common home and commercial practice, decreased the flavor quality both initially and during storage at 4 to 5°C. Pasteurization of raw goats' milk either at 63°C for 30 min or 72°C for 15 s within 1 d of milking ensures a better tasting product both initially and during storage at 4-5°C for 6 weeks than if the raw milk is aged for several days at 4-5°C before being pasteurized.

Goat Milk Products

Apart from goaty milk flavour, salty taste, poor scum formation due to finer fat globules and lack of agglutinating euglobulins and difficulty in fat separation are some of the technological problems related to goat milk processing into value added products.

Cheese

Goat milk cheese originated in Mesopotamia and developed later in the countries of the East Mediterranean basin, many of which emerged as large producers, consumers, and exporters of various types of cheeses made from small ruminants' milk. Nowadays, large numbers and many different varieties of goat milk cheeses are produced

worldwide, depending on diversity of locality, milk composition, and manufacturing techniques.

In the European Community, the originality of goats' and sheep's milk products is protected by the legislation on the Protected Designation of Origin (PDO) and the Protected Geographic Indications (PGI). International rules are opportune in order to protect the typical products, their specific characteristics, and their biodiversity, encouraging the permanent residence of the population in the rural areas, especially in the less favorite areas. Greece and France have by far the largest goat cheese production and, along with Italy and Spain, are also noted for their sheep milk cheeses. Excellent cheeses are made from sheep's or goats' milk or from mixtures of the two (See table).

Goat milk is the proprietary item for a few varieties of soft, hard and semi-hard cheese which arebeing marketed as Premium cheese in many European countries. Greece and France have the largest goat milk cheese production. Ripened goat milk cheeses are characterized by a piquent and peppery sharp flavour due to the presence of greater proportion of short and medium chain fatty acids. Most goat cheese varieties are soft cheeses consumed fresh, set by biological acidification or by an acid (hydrochloric, lactic, vinegar, lemon, lime, etc.) coagulation process, usually aided by low amounts of rennet, that is, lactic-type cheeses. There are also varieties consumed after ripening, generally made by the enzyme (rennet; chymosin) setting process.

Goat Milk Cheese manufacturing Process

Cheddar cheese may not be made from goat milk because the term"Cheddar cheese" has originated from cheese made only from cow milk. However, it can be and has been manufactured using goat milk, even if the latter has some problems of attaining the same level of moisture content as well as the firmness in texture of the cheese. These difficulties are due to its naturally soft curd body formation and lack of αs1-casein content in goat milk, which is considered the primary casein to attain firmness of the curd. An example of the manufacturing steps of goat Cheddar cheese adapted from the University of Wisconsin, Madison, Wisconsin, is presented below.

Mozzarella is a famous pasta filata cheese with particular functionality in both the unmelted and melted stages. The manufacture of goat milk Mozzarella is after overnight storage at 4°C, the milk was heated to 32°C in a cheese vat. After inoculation with a starter culture, the milk ripened for 30 min; then chymosin powder was added. The milk was agitated for 1 min and set for 30 min. The coagulum was cut with a 0.6 cm wire knife and allowed to cure for 5 min. The curds were then stirred gently for 15 min followed by cooking at 39°C for 40 min. At the end of cooking, the whey (pH 6.3 to 6.4) was drained. When the pH was decreased to 5.3, the curd was stretched and kneaded in multi directions for 5 min in water at 70 to 80°C. The plasticized curd was molded into blocks, cooled to 20°C, and brine salted (140 g of NaCl/l) for 1h. Finally,

the curd blocks were dried with paper towels, vacuum packed, and stored at 4°C for up to 8 weeks.

Whey Cheese

A brown whey cheese named Geitost or Gjetost is produced. It is a solid cheese obtained by heat evaporation of whey mixed with goat milk and cream, at 25%. The whey comes from rennet coagulation of goat milk and the resulting para casein fraction is used for the production of sodium caseinate or as animal feed. Due to the high lactose content, the processing results in a brown color and a sweet, cooked, and caramelized colour.

The well-known Ricotta cheese can be made from the whey of goat Semicotto cheese. Filtered whey is heated at 85–90°C. After coagulation of whey proteins, a rest period of 10–15 min and packaging, can be marketed. Whey cheeses made from the whey of small ruminants' hard-type cheese with or without supplementation milk and/or cream are manufactured in Greece by coagulation of whey proteins by heat, for example,Myzithra, Anthotyros and Manouri. The manufacturing stages of Kopanisti cheese, which is a goat whey cheese, unlike its namesake Greek cheese, mentioned earlier. Whey is mixed with fresh goat's milk at a ratio of 10–20% and is then heated to 80–85°C for the coagulation of whey proteins. The whey protein curd is kneaded repeatedly and salted; sometimes some spices like black cumin are added. Ripening is carried out in earthenware containers.

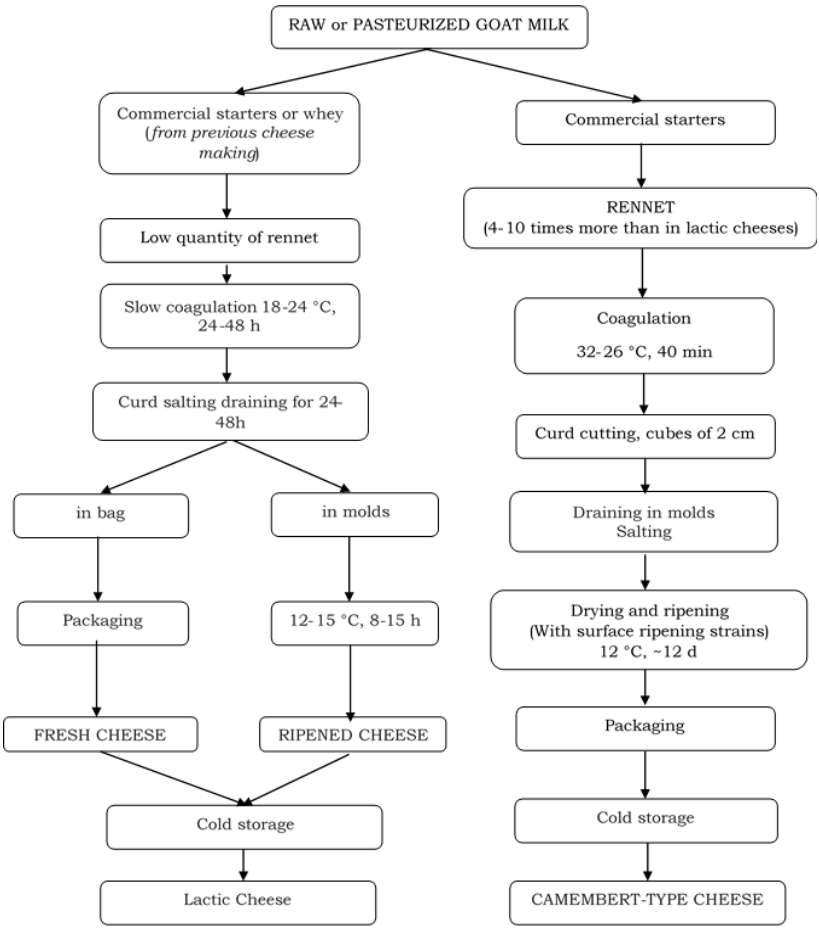
Paneer & Chhana

The method of manufacturing of paneer from goat milk extensively studied and standardized at Central Institute for Research on Goats, Makhdoom. Fresh goat milk is heated to 87-88°C and milk is coagulated by adding citric acid granules (0.15% W/W). The yield (13.31-19.34%), moisture (42.22-51.80%), protein (17.86-21.88%), fat (24.50-29.50%) and ash contents (1.53-2.33%) were reported to vary depending on the composition of milk from which paneer was prepared. Freshly prepared paneer had no goaty odour and salty taste.

"Chhana" is a heat and acid coagulated traditional Indian product that can be produced from goat milk. For making "Chhana" fresh milk is boiled and then cooled to around 70°C and coagulated using either the previous day's sour whey or citric acid or lactic acid. The coagulum is filtered through fine cloth and is then used as a base for the manufacture of sweets in India.

Flow diagram for some of the varieties of Goat milk cheese

1. Soft Goat Milk Cheese



2. Semi-hard and Hard Goat Milk Cheeses

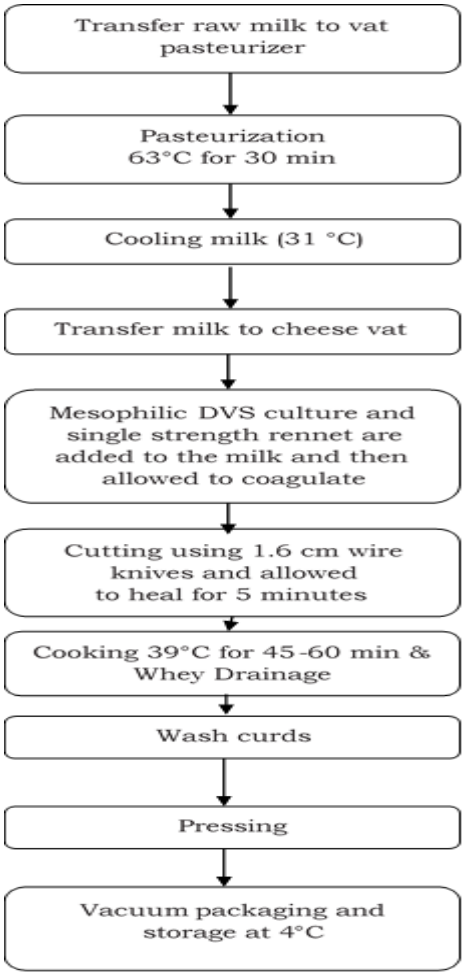


Table 6. Some Goat milk chesses and their composition

Origin	Cheese variety	Consistency	Fat (%DM)	Moisture%	Raw Material
France	Brocciu	Semi soft	25	Sheeps/goat milk whey	
	Chabichou du Poitou	Soft	45	50 max	Goats' milk
	Crotin de Chavignol	Semi hard	45	53 max	Goats' milk
	Le-Mothe St-Heraye	Soft	45	55 max	Goats' milk
	Saint-Maure de	Soft	45	55 max	Goats' milk
	Selles sur Cher	Soft	45	41 max	Goats' milk
	Picodon de la Drome	Soft	45		Goats' milk
	Pouligny Saint Pierre	Soft	45	40 max	Goats' milk
	Rocamadour	Soft	45		Goats' milk
	Valencay	Soft	45	55 max	Goats' milk
Greece	Abthotyros	Soft or dry	65, 45	70,40	Sheep and/or goat whey
	Feta	Soft	45	53	Sheep's and 5–10% goats' milk
	Formaella	Hard	50	33	Sheep's and/or goats' milk
	Galotyri	Soft	47	71	Goats' and/or sheep's milk
	Graviera of Crete	Hard	38	40 min	Goats' and sheep's milk
	Kaseri	Semi-hard	45	42 avg	Goats' and sheep's milk
	Kopanisti	Soft	48	60 avg	Cows'/sheep's/goats' milk or
	Ladotyri	Hard	47	34	Sheep's and/or goats' milk
	Manouri	Soft	52	76	Sheep and/or goat whey
	Metsovone	Hard	44	42	Sheep's and/or goats' milk
India	Paneer type	Soft	53		Goats' milk
Israel	Goats' Cheese	Soft	45	66	Goats' milk

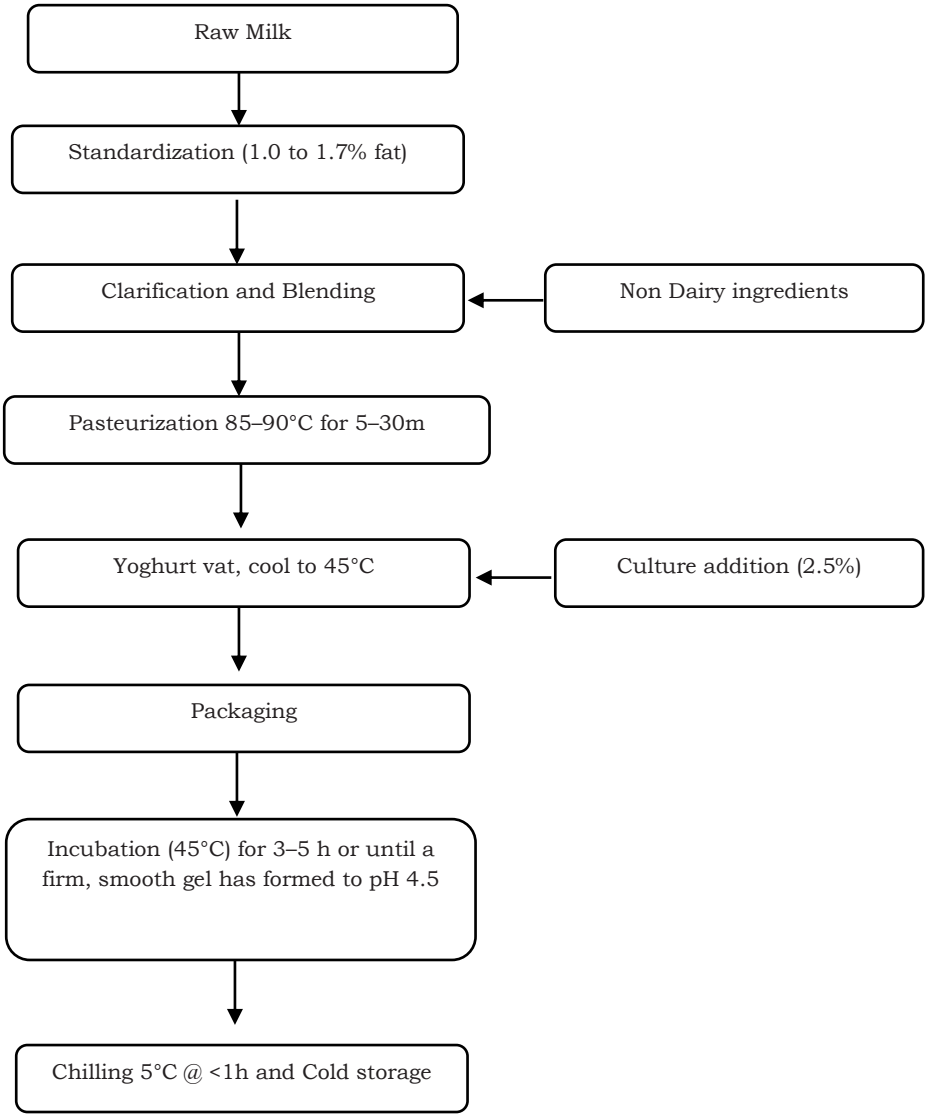
Italy	Apulian Cacioricotta	Soft	29		Goats' milk
	Cacioricotta	Soft	31		Sheep's and/or goats' milk
	Riccotta	Semi Soft	25		Sheep's and/or goats' milk whey
Norway	Gammelost		5		Goats' milk
	Gjetost	Semi Soft	38	13.4	Goats' milk whey
Spain	Cabrales	Soft	31		Blend cows'/sheep's/goats' milk
	Iberico	Hard/oily			Blend cows'/sheep's/goats' milk
	Ibores	Hard	59		Goats' milk
	Majorero	Hard	50		Goats' milk
	Trochon	Semisoft			Sheep's and/or goats' milk
	Valdeteja	Hard	73		Goats' milk
Mexico	Anejo Enchilado	Hard			Goats' milk

Fermented Milks

Yoghurt: Various types of fermented milks that are low pH products with specific texture can be produced from goat milk using specific starters and incubation conditions. Goat milk yogurt was one of the traditional products from countries where fermented dairy foods originated. Nowadays, there is a target market of goat yogurt for individuals who look for more nutritional benefits than those of cow milk, or are allergic to cow milk protein, or simply enjoy the flavor of goat milk products and usually are willing to pay high prices for certain goat milk products.

One of the main problems in the manufacture of goat milk yogurt is the weak texture expressed as a lack of consistency in curd tension or viscosity upon agitation compared to cow yogurt. This is due to the difference in the protein composition between the two milks, especially in casein contents. Again, the variability of milk produced by various goat breeds plays a significant role. Goat milk from certain breeds needs fortification in respect to protein, that is casein, and in some instances the processing conditions have to be modified to achieve products acceptable to the consumer.

Flowchart for manufacture of set-type goat milk yogurt



Kefir: Kefir is an acidic, slightly foamy alcoholic milk beverage made from pasteurized and fatstandardized or defatted sheep or goat milk, which is a result of yeast-lactic fermentation by symbiotic lactic acid bacteria and yeast on to "kefir grains." The finished kefir usually contains 0.6–0.8% lactic acid, 0.5–1.0% alcohol, and carbon dioxide. These products, which have been traditionally produced in Eastern Europe, are very popular due to their particular flavor and texture and because they are considered as healthy and stimulatory food. Standardized and homogenized milk was heated at 90°C for 10 min, then cooled to 22°C and inoculated with starter cultures, that is, DVI commercial cultures or traditional grains preserved in saline solution. The latter had been reactivated by three cycles of culturing in sterile milk at 22°C for 18 h. Fermentation was carried out at 22°C until pH~4.4, usually within 16 to 18 h. Finally, the fermentate was transferred to the cold store. Fermentation of goat milk with kefir grains decreased goat flavor but, in general, goat milk kefir had lower viscosity and sensory scores than its sheep or cow counterpart and the same holds true for goat kefir fortified with SMP, WPC, or inulin.

Acidophilus Milk: Acidophilus milk can be made by the activity of Lactobacillus acidophilus, which is capable of converting a greater proportion of the lactose to lactic acid. It is pasteurized milk or low-fat milk inoculated with Lactobacillus acidophilus, which destroys other competing bacteria antagonistic to man in the lower intestine. These organisms have the ability to implant themselves in the

large intestine, survive the low surface tension, and change nutrients. In the past the popularity of this product was limited by the flavor developed during fermentation. A more recent product has overcome this difficulty by adding live organisms to pasteurized milk and refrigerating to prevent subsequent fermentation and flavor development. Refer table for operational conditions.

Buttermilk: Buttermilk is usually made from skim milk using the byproduct from churning butter out of sour cream. A type of Arian produced traditionally in Turkey is a type of buttermilk. It is a byproduct obtained after manufacture of butter from the churning of diluted goat milk yogurt. After removal of butter, the remaining liquid part is known as "Turkish buttermilk" or "yayik ayrani"

Sweet Goat Milk Products

Sweet products made of goat milk are popular in Mexico and India. In Mexico, the "Cajeta," a thick liquid of caramelized milk with sugar added, is popular and sold as such or dried as small tarts. In Latin American countries, other sweets made of goat milk, called "Dulces," are produced in a similar way. "Chakka" is a concentrated product of India obtained after draining the whey from a fermented dairy product. It is mixed with sugar and other condiments to formthe popular dessert "Shrikhand".

Fat-Rich Goat Milk Products

Various butter-like products are produced in East Mediterranean countries and India from goat milk. Butter from goat milk is produced mainly in south eastern Turkey and in areas of the Black Sea. The latter is called "Trabzon" butter and is ripened in wooden barrels or earthenware jugs. A well-known product of this category in Turkey is "Yayik" butter produced from goat, sheep, or cow yogurt. "Ghee or Samen" that is butteroil from melted butter, is also produced from goat milk in the Middle East and India.

Frozen Goat Milk Products

Ice cream is successfully manufactured from goat milk. Three formulations for three flavors of goat ice cream are presented as follows (i) French vanilla mix with 14% fat, 10% MSNF, 18% sweetener (12% sucrose, 6% 36-dextrose equivalent corn syrup solids), 1.4% egg yolk solids, and 0.25% stabilizer-emulsifier; (ii) chocolate mix with 14.6% fat (0.6% cocoa fat), 9% MSNF, 20% sweetener (14% sucrose, 6% 36-DE corn syrup solids), 3% medium fat cocoa, and 0.22% stabilizer-emulsifier; and (iii) premium white mix with 15% fat, 10% MSNF, 18% sweetener, and 0.25% stabilizer-emulsifier. Manufacturing of three types of low-fat soft-serve goat milk ice creams using whole (3.64% fat), reduced (2% fat), and skim (0.71% fat) goat milk, which were formulated with a commercial powdered vanilla flavor pre-mix containing 0.25% fat is also possible from goat milk.

Table 7. Processing parameters of some of the goat milk fermented milk products.

Products	Milk type	Culture	Type of inoculums	Rate of inoculation (%)	Incubation		Stop incubation at	
					°C	Time, h	pH	%TA
Buttermilk	Skim or low fat	*S. lactis, S. cremoris*	Bulk start or direct set	0.5–1.0 as directed	22	14–16	4.5	0.8
		L. citrovorum, S.diacetylactis			22	12-16	4.5	0.8
Acidophilus	Skim or low fat	*L. acidophilus*	Bulk start	0.5	37-44	18–24	3.8	1.0
Sour dip	Half-n-Half (11% fat)	Same as for buttermilk*	Bulk start or direct set	1.0	22	14–16	4.8	0.7
Kefir	Whole	*S. kefir, T. kefir, L. caucasius, S. lactis,*	Kefir grains	As directed	22 followed by 1	12	4.5	0.8
Yogurt	Skim or low fat	*S. thermophiles, L. bulgaricus*	Individual cultures or direct set	1.25 each or as directed	45.6	5-6	4.2	0.9

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