Asian Journal of Animal Sciences 5 (1): 56-63, 2011
ISSN 1819-1878 / DOI: 10.3923/ajas.2011.56.63
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Quality and Utility of Goat Milk with Special Reference to India: An Overview

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ABSTRACT

The aim of this study was to project the importance and significance of goat milk and milk products with special reference to India. Goats are important component of livestock industry and play a vital role in the socio-economic structure of rural poor. South Asian countries including India, Bangladesh and Pakistan are the major producers of goat milk, whereas, in Europe the most developed dairy goat industry is in France, Greece, Spain and Italy. Indian breeds such as Jamunapuri, Barbari, Beetal, Surti, Jakhrana produce fairly good amount of milk. Goats in Greece and Sardinia produce milk with higher level of total solids, fat and protein. Breeds like Alpine and Saanen produce milk with lower fat, protein and casein contents. Goat milk contains higher amount of Ca, Mg and P than cow and human milk but vitamin D, vitamin B_{12} and folate contents are less. Goat milk is recommended for infants, old and convalescent people. Three fatty acids viz., caproic, caprylic and capric have great medicinal values for patients suffering from a variety of ailments. In this review we have discussed the goat population and goat milk production, gross composition with nutritive value in terms of energy, minerals and vitamin contents goat milk, details fraction of protein and fat, characteristics of goat milk, medicinal value of goat milk, goat milk products and marketing potential of goat milk and milk products.

Key words: Goat milk, composition, products, characteristics, marketing

INTRODUCTION

Goats form an important component of livestock industry and play a vital role in the socio-economic structure of rural poor. India has the second highest goat population in the world which is around 120 million constituting about 15% of World's goat population only next to China (FAO, 2004). There are twenty well defined breeds of goats in India, although 70% population are non-descript and meat type. Some of the breeds such as Jamunapuri, Barbari, Beetal, Surti, Jakhrana produce fairly good amount of milk. Goats in India produce around 2.76 million tones of milk which is 22.28% of World's production and 3% of total milk produced in the country (FAO, 2004). Among the Asian nations, South Asian countries including India, Bangladesh and Pakistan are the major producers of goat milk, whereas, in Europe the most developed dairy goat industry is present in France, Greece, Spain and Italy (Table 1).

Composition and characteristics of goat milk: The yield and composition of goat milk vary widely and this variation is attributed to breed, parity, stage of lactation, milking time

Table 1: Goat population and goat milk production in selected countries of the world in 2004 country goat population contribution to milk production contribution to (Million) world's population (Million tons) world's production

Countries	Population	Production	Population	Production
Asia				
Bangladesh	34.50	4.41	1.328	10.72
China	183.36	23.42	0.250	2.02
India	120.00	15.33	2.760	22.28
Pakistan	54.70	6.99	0.658	5.31
Turkey	6.70	0.86	0.280	2.26
Africa				
Kenya	12.00	1.53	0.097	0.78
Nigeria	28.00	3.58	No records	-
Sudan	42.00	5.36	1.295	10.45
Europe				
France	1.20	0.15	0.552	4.46
Greece	5.36	0.68	0.450	3.63
Italy	0.96	0.12	0.115	0.93
Spain	3.00	0.38	0.455	3.67
Others				
Brazil	9.09	1.16	0.135	1.09
Australia	0.40	0.05	No records	-
World	782.94	-	12.388	-

Source: www. fao.org

(Agrawal and Bhattacharyya, 1978; Jenness, 1980; Kala and Prakash, 1990; Pal *et al*., 1996, 1997), age (Mittal, 1979), geographical location, season, diet, health and management of goats (Sachdeva *et al*., 1974; Singh and Sengar, 1990; Singhal and Mudgal, 1985). High levels of fat, total solids and protein in milk have been reported for the West African dwarf goat, pygmy goats of Oregon, Black Bengal and Barbari of India. Indigenous goats in Greece and Sardinia have been reported to produce milk richer in total solids, fat and protein. Breeds like Alpine and Saanen produce milk with lower fat, protein and casein contents mainly because of higher milk yield in these breeds (Tziboula-Clarke, 2003). Goat milk produced during winter was found to contain more fat, Total Solids (TS) and solids-not-fat than the milk produced during summer (Pal *et al*., 1994). Similarly, with the progress of lactation period fat, ash and total solids are reported to increase while lactose content decreases (Kala and Prakash, 1990; Pal *et al*., 1996). Gross composition and nutritive value in terms of energy, minerals and vitamin contents of goat milk, cow milk and human milk is presented in Table 2. Total solids, fat, crude protein, lactose and ash contents of goat milk are almost similar to cow milk but there are important differences in the individual fatty acids and casein fractions and fat globule sizes. Three medium chain fatty acids named after goat: caproic (C6), caprylic (C8) and capric (C10) contribute to 15% of total fatty acids content in goat milk in comparison to 5% in cow milk (Haenlein, 1993). Fat globules of goat milk are smaller in size and do not coalesce upon cooling because of lack of agglutinin, which is responsible for the aggregation of fat globules in cow milk. In a recent study, it has been found that average diameter of individual fat globules in goat milk is 2.76 μm, smaller than the mean diameter of 3.51 μm in cow milk. Ninety percent of the fat particles in goat milk were less than 5.21 μm compared to cow milk fat particles, 90% of which were less than 6.42 μm (Tziboula-Clarke, 2003).

Table 2: Composition of goat, cow and human milk

Gross	Goat	Cow	Human
Composition			
Water (%)	87.5	87.7	86.7
Fat (%)	4.0-4.5	3.8	4.1
Protein (%)	3.2	3.3	1.3
Lactose (%)	4.6	4.7	7.2
Minerals (mg/100 g)			
Na	34.0	50.0	14.0
K	180.0	150.0	58.0
Ca	129.0	120.0	34.0
Mg	20.0	12.0	3.0
P	106.0	95.0	14.0
Fe	0.04-0.1	0.05	0.07
Cl	130.00	95.0	42.0
Vitamins (per 100 g)			
Vitamin A(IU)	185.0	126.0	241.0
Thiamin (mg)	0.05	0.04	0.014
Riboflavin (mg)	0.14	0.16	0.04
Pantothenic acid (mg)	0.31	0.314	-
Niacin (mg)	0.28	0.08	0.18
Vitamin B (mg)	0.05	0.04	0.01
Folic acid (mg L^{-1})	6.0	50.0	56.0
Vitamin B_{12} (mg)	0.05	0.14	0.14
Biotin (mg)	2.00	2.00	0.70
Vitamin C (mg)	1.50	1.50	1.00
Vitamin D (mg)	0.06	0.03	0.025

Source: Anjaneyulu *et al*. (1985), Darnton-Hill *et al*. (1987), Chandan *et al*. (1992)

Because of predominance of smaller fat globules in goat milk, it is easier to digest than cow milk and this may be attributed to faster lipase activity on smaller fat globules due to greater surface area (Chandan *et al*., 1992). Hence, goat milk is recommended for infants, old and convalescent people. Moreover, these three fatty acids viz., caproic, caprylic and capric are reported to have great medicinal values for patients suffering from a variety of malabsorption, childhood epilepsy, cystic fibrosis and gallstones (Haenlein, 1992). Ohiokpehai (2003) also mentioned that goat milk had good nutritional and medicinal qualities.

Like cow milk, goat milk caseins have the same four species of αS_1, αS_2, beta and kappa but in different proportions (Table 3). It has been reported that beta casein is the major component of goat milk casein, whereas, αS_1 is the major component of cow milk casein. Level of αS_2 casein is relatively higher in goat milk but total of αS_1 and αS_2 casein fractions together are lower than αS_1 fraction alone of cow milk. Such differences might contribute to soft curd forming properties, better digestibility and least allergic to children.

Lactoperoxidase (LP), a protein present in goat milk was found to be effective against a battery of bacteria causing cholera (*Vibrio cholerae*), typhoid (*Salmonella typhi*), pneumonia (*Klebsiella pneumoniae*), dysentery (*Shigella dysenteriae*) and food poisoning (*Staphylococcus aureus*). Similar studies using bovine LP showed that goat milk alone is antibacterial (Anonymous, 1998).

Table 3: Comparison of proteins of goat and cow milk

	Concentration (%)	
Protein	Goat milk	Cow milk
Total Casein	2.33-4.63	2.4-2.8
β-Casein[a]	06-64.0	37.5-39.3
K-Casein[a]	15.0-29.0	8.3-14.3
α S_1-Casein[a]	0-28.0	50.0-53.6
α S_2-Casein[a]	10.0-25.0	12.5-14.3
Whey proteins	0.37-0.70	0.5-0.7
β-Lactoglobulin[c]	39.2-72.1	40.0-57.1
α-Lactalabulin[c]	17.8-33.3	12.0-24.3
Serum albumin/lactoferrin[c]	5.1-21.5	4.0-5.71
Immunoglobulins[c]	4.6-21.4	10.0-25.7

a % Total Casein, b absence of β or α S_1-caseins in milk from animals carrying the respective null alleles. c% Total whey proteins. Source: Compiled and arrived at from Tziboula-Clarke (2003) and Wong *et al.* (1998)

Goat milk is reported to contain higher amount of Ca, Mg and P than cow and human milk but vitamin D, vitamin B_{12} and folate contents are less though distribution of other vitamins is comparable in goat and cow milk (Table 2). Infants fed exclusively with goat milk should be ensured oral supplementation of folic acid to avoid folate deficiency in the long run.

Goat milk products: An important characteristic of goat milk is the unique 'goaty' flavour which is attributed to difference in the fat fraction of goat milk and to the relatively higher proportion of short and medium chain fatty acids (Tziboula-Clarke, 2003). Moreover, salty taste, poor scum formation due to finer fat globules and lack of agglutinating eugloubulines and difficulty in fat separation are some of the few technological problems related to goat milk processing into value added products (Agnihotri and Prasad, 1993).

Cheese: Goat milk is the proprietary item for a few varieties of soft, hard and semi-hard cheese which are being marketed as Premium Cheese in many European countries. Greece and France have the largest goat milk cheese production (Table 4). Ripened goat milk cheeses are characterized by a piquant and peppery sharp flavor due to the presence of greater proportion of short and medium chain fatty acids in goat milk fat (Tziboula-Clarke, 2003).

In India, cheese prepared exclusively from goat milk is hardly available. However, technology has been developed for cheddar type cheese using admixture of buffalo and goat milk (80:20 or 90:10). Addition of 10-20% goat milk improves the sensory attributes of cheddar type cheese prepared from buffalo milk. In such admixture, goat milk acts as synergistic tonic in the manufacture of this type of cheese by improving rate of acid development, reducing cheddaring time, increasing moisture retention in cheese curd, stimulating growth of starter microflora, improving the rate of glycolysis and lipolysis, reducing hardness and improving the cohesiveness of cheese and eliminating the incidence of bitterness (Kanawjia *et al.*, 1992; Singh *et al.*, 1992a).

Direct acid mozzarella cheese manufactured from admixture of goat and buffalo milk (50:50) showed maximum stretchability and sensory scores. The meltability and fat leakage were found to be optimum (Sabikhi and Kanawjia, 1992). Direct acid mozzarella cheese prepared exclusively from goat milk with acceptable meltability and stretchability values has been reported

Table 4: Some goat milk cheeses and their composition

Country of origin	Cheese variety	Consistency	Fat (%DM, min)	Moisture (%)	Raw material
France	Cortinde Chavignol	Semi-hard	45	53 max	Goat milk
	Chabichou	Soft	45	50 max	-
	Le-Mothe St –Herage	-	45	55 max	-
	St-Maure	-	45	55 max	-
	Valencay	-	45	55 max	-
	Selles sur Cher	-	45	41 max	-
	Pouligny St Pierre	-	45	40 max	-
	Picodon de la Drme	-	45	-	-
	Rocamadour	-	45	-	-
Greece	Feta	Soft	45	53	Sheep+5-10% goat milk
	Kaseri	Semi-hard	45	42(average)	Goat+ sheep milk
	Graviera of Crete	Hard	38	40 min	-
	Kopanisti	Soft	48	60 average	Cow/sheep/goat milk or mixtures
	Galotyri	Soft	47	71	Goat and / or sheep milk
	Metsovone	Hard	44	42	-
	Ladotyri	-	47	34	-
	Formaella	-	50	33	-
Israel	Goats' cheese	Soft	45	66	Goat milk
Spain	Valideteja	Hard	-	-	-
	Cabrales	Soft	31	-	-Blend of cow/sheep/goat milk
	Iberico	Hard/oily	-	-	-
	Majorero	Hard	50	Goat milk	
Mexico	Anejo Enchilado	Hard	-	-	-

Source: Tziboula-Clarke (2003)

(Pal and Agnihotri, 2000). It has also been reported that supplementation of buffalo milk with goat milk (at 5, 10 and 15% levels) enhanced flavour development in Gouda cheese. Supplementation with goat milk enhanced the moisture retention, total solid recovery and yield of cheese. A faster rate of proteolysis and lipolysis was observed for goat milk supplemented cheeses which increased with increasing levels of goat milk (Singh *et al*., 1992a).

Paneer: Paneer, an acid and heat coagulated product (similar to American white cheese), is conventionally made from buffalo milk and it is used widely in India for preparation of a variety of culinary dishes. The method of manufacturing paneer from goat milk has been extensively studied and standardized at Central Institute for Research on Goats, Makhdoom (Prasad *et al*., 1990; Pal *et al*., 1994, 1997; Agnihotri and Pal, 1996a; Agnihotri and Pal, 1997). 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 (1.53-2.23%) 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. The body of the paneer was semi-hard with smooth texture and no air pockets. The product had wider acceptably and great demand among the consumers.

Other dairy products from goat milk: Various indigenous dairy products viz., khoa, a heat dessicated base material used for preparation of a variety of sweetmeats (Peda, Burfi, Gulabjamum, Kalakand etc.); chana-based sweets (Sandesh); Shrikhand, a fermented, sweetened and flovoured

dairy product have been tried using goat milk as raw material with varying success (Jailkhani and De, 1979, 1980; Singh *et al*., 1992a; Agnihotri and Pal, 1996b; Agnihotri and Pal, 1997). Goat milk ghee prepared by ripening the cream with lactic starter had a fine texture and mild acid flavor (Singh and Gupta, 1982). It was further reported that goat milk ghee could keep well for 4 months when it was prepared by indigenous method and for 10 months at 30°C when prepared by creamery butter and direct cream method (Arora and Singh, 1987). Besides these, Ohiokpehai and Jagow (1998) reported manufacture of Madila (sour milk), a popular food in Botswana from goat milk. Madila is produced by natural fermentation of lactose to lactic acid. Such products may be liquid or semi-solid and can be flavored with artificial flavourings or fruit juices.

Marketing potential of goat milk and milk products: Medicinal value of goat milk has been documented in Ayurveda (Indian Tradional Medicine) and Bhavprakash and goat milk was recommended as an effective dietary item for the patients suffering from tuberculosis, dysentery, cough and cold and certain gynaecological disorders. In the last decade, there has been an increased interest for goat milk production and conversion to value added products. Goat milk consumption was encouraged within the EU countries by the introduction of quota on cow milk in 1984 (Tziboula-Clarke, 2003). In recent year, there has been a renewed interest in goat milk as an alternative milk source for people with cow milk intolerance (Tziboula-Clarke, 2003). There is increasing demand for organic and healthy dairy food worldwide including India. The marketing value of such products in developed countries is estimated around US $14180 million and it is rapidly growing on an average of 10-12% annually. In some countries the growth is expected to cross more than 30% (Rathinam, 2005). This trend of consumer interest in toxic residue-free milk will further benefit India, the highest goat milk producer in the world, where natural pasture grazing of goats predominates. Cheese industry in India is coming up in a big way and goat milk can be used as a major raw material for development of premium cheeses in the country following the path of France. In 1999, France produced 68,000 tones of goat milk cheese out of which more than 30% was for export and the rest for domestic consumption (Tziboula-Clarke, 2003). Moreover, because of its proven role in improving the quality of buffalo milk cheddar and mozzarella cheese, which is otherwise said to be unsuitable for these products, goat milk can prove to be a boon to Indian cheese industry (Singh *et al*., 1992b).

CONCLUSION

India having the second largest goat population and some of the great milch breeds like Jamunapari, Beetal, Surti, Barbari is the highest producer of goat milk in the world. In spite of good efforts in dairy development, the organized sector processes only about 15% of total milk produced in the country. No such data is available exclusively for goat milk. As the goat farmers are mostly unorganized and scattered and belong to the lower strata of the society, it is imperative to streamline the goat milk collection by establishing milk sheds in the home tract regions of the different milch breeds of goats especially in the states of Uttar Pradesh, Rajasthan and Kutch Region of Gujarat. This can be achieved through establishment of goat producers/breeders co-operative societies in the line of milk producers co-operative societies under operation flood projects. Such efforts will ensure supply of goat milk in bulk for industrial use and also augment the production of healthy goat milk and milk products.

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