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Original Research Article

The nutritional therapeutic values and chemical properties of goat milk

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ABSTRACT

Goat is known as poor man's animal. The fat globules are smaller in goat milk, which makes it easily digestible. Polyunsaturated fatty acids in goat milk fat, is mainly responsible for anticancerous behavior of goat milk. Although protein is somewhat low in goat milk than cow milk, the digestibility of goat milk protein is higher compared to cow milk protein. Taurine present in goat milk is reported to have inhibitory action on cardiovascular disease leads to synthesis of essential amino acids. Goat's milk contains less lactose than cow's milk, which is beneficial to lactose intolerance patients. Higher selenium concentration in goat milk, results in platelet regeneration when suffering from dengue fever. Bioactive peptides released during fermentation and invitro digestion are reported to produce antioxidant and antimicrobial peptides. Sialic acid present in caprine milk is also reported to help fast brain development. As compared to milk of other milch animals, goat's milk has great potential to prevent various diseases. Beside nutritional properties, goat milk possesses potent nutraceutical and Therapeutic properties making it most suitable for infants, older and convalescent people. In this review, strong nutraceutical power of caprine milk is briefly explored.

1. Introduction

An important characteristic of goats' milk is the unique 'goaty' flavour. This is attributed to differences in the fat fraction of goat milk. Although the composition and particularly the dominant position of the is not unlike that of cows' milk, a larger concentration of is found in goats' milk. These are the result of hydrolysis and their presence could lead to the development of desirable or undesirable flavours, depending on their type and concentration. In goats' milk, these free fatty acids are the main source of the characteristic flavour.[1] A number of have been identified and are considered responsible for the hydrolysis. Most of these enzymes can easily be inactivated by heat treatment. Other investigators attributed the characteristic 'goaty' flavour to the relatively higher proportion of short and medium chain-length fatty acids.[2]

From the technological point of view, it is clear that the differences in chemical composition and particularly the impact of casein genotype on the structure of the caprine casein micelles are sufficiently pronounced to explain the differences in the textural characteristics of cheeses and products.[2–5]

Different varieties of cheese, yoghurt, ice cream, fluid milk and milk powder are produced from goat milk. Goat milk has traditionally been known for its medicinal properties and has recently gained importance in human health due to easy digestibility and it's all round health promoting traits.[5] Goat milk has advantages over cow or human milk in having higher digestibility of protein and fat,

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alkalinity, buffering capacity, and certain therapeutic values in medicine and human nutrition. Due to lack of availability of cow milk, goat milk and its products provide important daily food sources of protein, phosphate and calcium in developing countries. Goat milk is considered as "self-homogenized" milk.[4]

Milk is a complex biological fluid produced by the mammary gland that has three main functions nutritional, immunologic, and physiological. Traditionally, goat milk has been considered a fundamental food in the diets of many cultures. Milk provides an easily accessible matrix, rich in a large variety of essential nutrients like minerals, vitamins, and easily with balanced amino acid profiles, important in supporting most body functions. Both human and animal studies indicate that is utilized more efficiently than cow fat. This feature of goat milk most likely relates to its unique enrichment in medium-chain fatty acids.

2. Nutritional and Therapeutic Values of Goat Milk

2.1. Digestibility and micronutrient absorption

The most appearing property of goat milk is superior digestibility and absorption of micronutrients. Digestibility of goat milk is highly enhanced by nature of the proteins and the fat molecules (Park et al., 2007).[6] Goat milk does not contain the protein agglutinin that promotes clustering of fat globules. The absence of clustering facilitates rapid digestion and absorption (Farah, 1991).[7]

2.2. Antimicrobial activity

Goat milk contains high levels of medium chain fatty acids, such as caprylic and capric acids. These fatty acids are highly antimicrobial. Capric and caprylic acids are used in dietary supplements to inhibit the growth of *Candida albicans* and other yeast species (Mwenze, 2015).[8]

2.3. Alkalinizes the blood and the intestine

Goat milk helps to increase the pH of the blood stream. It is the only dairy product with the highest amount of the L-glutamine. Acidic blood and low intestinal pH levels have been associated with fatigue, headaches, muscle aches and blood sugar imbalances (Mwenze, 2015).[8]

2.4. Less allergenic and brain development

In the USA and Canada the department of pediatrics has recommended that cow's milk be avoided for children between 0-6 months due incidences of allergy (Playfordet al. 2000).Sialic acid profile of goat colostrums milk is similar to human milk (Kumaret al., 2016) and helps in brain development.[9]

2.5. Dengue fever

Dengue fever is mainly transmitted to humans by *Aedesaegyptimosquito.* So, for treating this disease goat milk and milk products are mostly preferred. Deficiency of selenium and decrease in platelet count are the main complications of dengue fever. Goat milk as well as its products is richest source of selenium (Kumar et al., 2016).[9]

2.6. Growth factors for infants

Goat milk contains high levels of growth factors similar to those found in human milk making it an essential diet for the infants. The Transforming Growth Factors (TGF) has a physiological role in maintaining regular functionality of the infant (Playf ordet al., 2000).[10]

2.7. Prevention of inflammatory bowel disease

Oligosaccharides from goat milk are shown to have an anti-inflammatory effect. The expected decrease in body weight, increased colon size and extension of necrotic lesions are prevented by the oligosaccharides (Lara Villosladaet al., 2006).[11]

2.8. Cardiovascular diseases (CVD)

Goat milk is rich in medium chain triglycerides (MCT) including caproic, caprylic and capric acids. These MCT have a lowering effect on plasma cholesterol in rat models and act as anti-atherogenic(Davenport, 2002).

2.9. Prevention of milk allergy

The proteins αs_1 casein and β-lactoglobulinare important allergens in cow milk allergy. Since the content of αs_1casein is very high in cow milk but relatively low in goat milk, the latter has been suggested as an alternative milk source for cow milk allergies (Tomotakeet al., 2006).[12]

2.10. Immunomodulatory activity and immunity booster

Jirilloet al. (2010) showed immune modulatory effects from goat milk both in in vitro and human studies. The effects of goat milk on human blood cells in terms of nitric oxide (NO) and cytokine release. The results demonstrated that goat milk was able to activate NO release from blood cells as well as triggering of cytokine production.Selenium is one of the key component for the immune system functionality.[13]

2.11. Anti-carcinogenic effect

Goat milk has a high content of conjugated linoleic acid (CLA) (Jirilloet al., 2010). Anti-carcinogenic properties of CLA have been reported against mammary and colon cancer in animal models, as well as in vitro models of human

melanoma, colorectal and breast cancer (Palomboet al., 2002).[14]

2.12. *Effect on infancy intake*

Basnet et al. (2010) reported an infant was exclusively fed goat milk, which led to azotemia (abnormally high levels of nitrogen compounds in the blood), hypernatremia (electrolyte imbalance caused by elevated sodium levels) and hemorrhages in the brain but when it gave malnourished children (1-5 years) goat or cow milk, weight gain and fat absorption were similar in both groups.[15]

2.13. *Therapeutic value of goat milk*

Kullisaaret al. (2003) showed antioxidative and anti-atherogenic effects from fermented goat milk. Minerviniet al. (2009) developed fermented goat milk with a mixed starter culture which resulted in production of GABA and provoked an in vitro ACE-inhibitory activity, which counteract high blood pressure. Sannaet al. 2(005) used a mix of Streptococcus thermophilusand Lactobacillus delbrueckiisubsp. bulgaricuswhen fermenting goat milk which resulted in to a yogurt with a significant quantity of folate and good sensory attributes. IgA account for the majority of serum immunoglobulins.[16–18]

3. Chemical Compositions of Goat Milk

Composition of goat milk are vary according to changes in diet, individuals, season, breed, species, feeding managements, environmental conditions, stage of the lactation, locality and condition of the udder. Goat milk is similar to cow milk in its basic composition. Caprine milk contains 12.2% total solids, 3.8% fat, 3.5% protein, 4.1% lactose, and 0.8% ash. 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. Goat milk and cow milk have 3 to 4 times greater levels of protein and ash than human milk. Total solids and caloric values of goat, cow, and human milks are similar (Jenness, 1980; Chandanet al., 1992).[19,20] Goat milk differs from cow milk in having better digestibility, buffer capacity, alkalinity and therapeutic values. Fat of goat milk have higher physical properties i.e. surface tension, viscosity and specific gravity as compared to cow milk (Park et al., 2007)[21]

3.1. *Milk lipid*

Major differences between goat and cow milk is physicochemical structure and composition of milk fats. The fat globules range between 1 and 10 μm in both goat and cow milk (Silanikoveet al., 2010).[22] In respect to free lipids, goat milk has higher values than that of cow milk. Goat milk contains 97–99% of free lipids and 1–3%

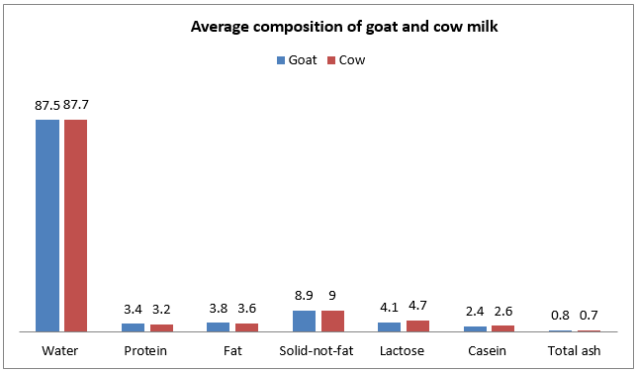

Fig. 1: Average composition of goat and cow milk. (Source: Park et al., 2007)[8]

bound lipids of total milk fat (Cerbuliset al., 1982).[23] Goat milk contained 96.8% triglycerides, 2.2% diglycerides and 0.9% monoglycerides. Goat milk is rich in short- and medium-chain fatty acids (FAs) compared to the cow milk (Luke and Keith, 1992; Silanikoveet al., 2010; Amigo and Fontecha, 2011).[4]

Table 1: Fatty acid composition (Per cent of total fatty acids) of goat milk (n=30) from Granadina goats and cow milk (n=30).

Fatty Acids	Goat milk	Cow Milk
Butyric acid	1.27	3.84
Caproic acid	3.28	2.28
Caprylic acid	3.68	1.69
Capric acid	11.07	3.36
Lauric acid	4.45	3.83
Myristic acid	9.92	11.24
Palmitic acid	25.64	32.24
Stearic acid	9.92	11.06
Oleic acid	23.8	21.72
Linoleic acid	2.72	2.41
CLA tot	0.68	0.4
α-linolenic acid	0.53	0.25
PUFA n-6	2.81	2.53
PUFA n-3	0.51	0.25
PUFA tot	4.08	10.49

The short-chain FAs represent 15-18%. The short- and medium-chain FAs are partly responsible for the characteristic “goaty” odor (Silanikoveet al., 2010; Amigo and Fontecha, 2011).[4,22] The medium-chain triglycerides were found to be 30.83% and 25.16% in goat and cow milk, respectively, whereas the long-chain triglyceride were 53.95% and 64.01% in the same order (Ruiz-Sala et al., 1996).[25] Cholesterol contents of goat, cow and human milk were reported as 11, 14, and 14 mg/100 g milk, respectively (Posati and Orr, 1976).[26] Goat milk consists more of the linoleic and arachidonic acids and CLAs (Luke and Keith, 1992; Amigo and Fontecha, 2011).[1,27] Total CLA content of goat milk is 35.75 mg/100 g while it is only 15.62 mg/100 g

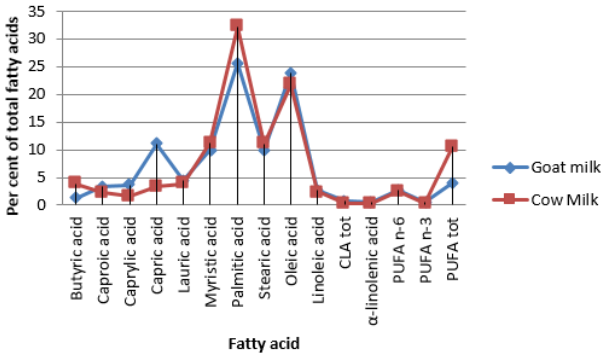

Fig. 2: Fatty acid (Source: Ceballoset al., 2009)[24]

in cow milk (Ceballos et al., 2009).[24]

4. Protein (Amino acids)

The amounts of free amino acids are different between goat and cow milk. The higher content of cysteine (derived from cystine) has been shown to improve intestinal absorption of copper and iron in a rat model of malabsorption syndrome (Barrionuevoet al. 2002; Haenlein, 2004).

Table 2: Average amino acid composition (g/l00 g milk) in proteins of goat and cow milk.

Amino acids	Goat milk	Cow milk
Essential amino acids		
Tryptophan	0.044	0.046
Threonine	0.163	0.149
Isoleucine	0.207	0.199
Leucine	0.314	0.322
Lysine	0.290	0.261
Methionine	0.080	0.083
Cystine	0.046	0.030
Phenylalanine	0.155	0.159
Tyrosine	0.179	0.159
Valine	0.240	0.220
Non-essential amino= acids		
Arginine	0.119	0.119
Histidine	0.089	0.089
Alanine	0.118	0.113
Aspartic acid	0.210	0.250
Glutamic acid	0.626	0.689
Glycine	0.050	0.070
Proline	0.368	0.319
Serine	0.181	0.179

(Source: Posati and Orr, 1976)

Taurine is the most representative free amino acid in goat milk and the concentration is much higher than in cow milk (Huxtable, 1992;Sarwaret al., 1998; Tripaldiet al., 1998; Belewu andAiyegbusi, 2009).[28–30] There are two distinct phases of milk proteins; micellar phase composed of casein and a soluble composed of whey proteins. The caseins constitute about 80% of the proteins and are classified as αs_1, αs_2, β and κ-caseins, while the major whey proteins are β-lactoglubulin and α-lactalbumin (Slacanacet al., 2010).[31] Goat milk contains lower amounts of the αs-casein, higher amounts of the β-casein fractions and equal amounts of the κ-casein fractions compared to cow milk (Park et al., 2007).[21] The casein micelles in goat milk differ from those in cow milk in having greater β-casein, more calcium & phosphorus and lower heat stability (Jenness, 1980).[20] Two types of β-lactoglobulin have been identified in goat milk and three variants of α- lactalbumin (Moatsouet al., 2005).[17]

5. Lactose

Lactose is a major carbohydrate present in goat milk but content slightly low as compared to cow milk (Slacanacet al., 2010).[31] 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 (Slacanacet al., 2010).[31] Milk oligosaccharides are thought to be beneficial to human nutrition because of their prebiotic and anti-infective properties (Kunz et al., 2000).[32]

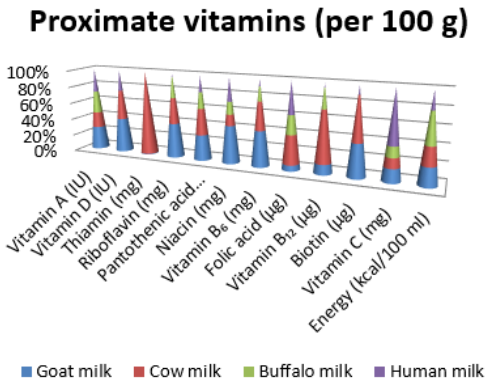

Fig. 3: Proximate vitamins (per 100 g) (Source: Park et al., 2007)[21]

6. Mineral and Vitamins

Goat milk is reported to have higher content of potassium, calcium, chloride, phosphorus, selenium, zinc and copper than cow milk (Slacanacet al., 2010).[31]Goat milk has a higher vitamin A content than cow milk because goats convert all β-carotene from foods into vitamin A (Geissler and Powers, 2011).[33]

Both goat and cow milk have low concentrations of vitamin B6 and vitamin D, which are both important during infancy (Park et al., 2007). Goat milk is deficient in folic

Table 3: Proximate vitamins (per 100 g) content in milk of various species.

Component	Goat milk	Cow milk	Buffalo milk	Human milk
Vitamin A (IU)	185	126	177	190
Vitamin D (IU)	2.3	2.0	-	1.4
Thiamin (mg)	0.07	10.05	0.04	0.02
Riboflavin (mg)	0.21	0.16	0.13	0.02
Pantothenic acid (mg)	0.31	0.32	0.20	0.20
Niacin (mg)	0.27	0.08	0.09	0.17
Vitamin B (mg)	0.05	0.04	0.02	0.01
Folic acid (μg)	1.0	5.0	3.3	5.5
Vitamin B_{12} (μg)	0.07	0.36	0.14	0.03
Biotin (μg)	1.5	2.0	-	0.40
Vitamin C (mg)	1.29	0.94	1.00	5.00
Energy (kcal/100 ml)	70.0	69.0	117.0	68.0

Table 4: Proximate vitamins (per 100 g) content in milk of various species

Component	Goat milk	Cow milk
Sodium	41	44
Potassium	181	152
Calcium	134	122
Magnesium	16	12
Phosphorus	121	119
Sulphur	28	32
Iron	0.07	0.08
Chloride	150	100
Se (μg)	1.33	0.96
Copper (mg)	0.05	0.06
Manganese (mg)	0.03	0.02
Zinc (mg)	0.56	0.53
Iodine (mg)	0.02	0.02

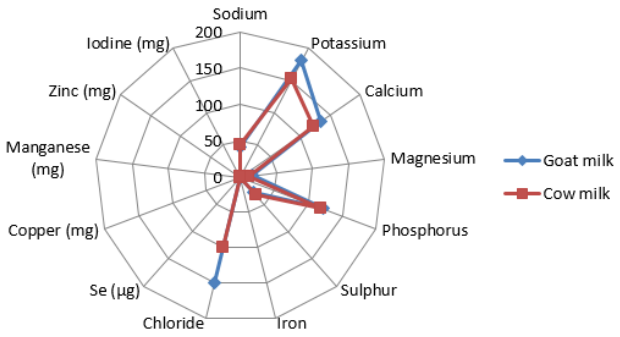

Fig. 4: (Source: Park et al., 2007)[21]

acid and vitamin B12, which cause 'goat milk anemia' (Jenness, 1980; Park et al. 2007).[20,21] Vitamin C is a well-known water-soluble antioxidant that is found in greater amounts in goat milk than in cow milk (Geissler and Powers, 2011).[33]

7. Conclusion

Although goat milk is similar to cow milk in its basic composition, the significance of goat milk and its products in human nutrition and well-being can never be underestimated. Goat milk products provide essential nutrients in human diet, as well as income sources for the survival of mankind in ecosystems of many parts of the world. Goat milk and its product is a rich source of more bioavailable proteins, fats, vitamins and minerals with great suitability for infant foods. Due to its high nutritive value and physiological properties, goat milk should be promoted in the developing countries like India, where malnutrition and diseases are more prevalent along with high poverty levels. The maintenance cost, general management and feeding of dairy goat is very low. But commercialization and utilization of goat milk is still lacking in developing countries. And scientific community has lack of information related to its use for commercialization.

8. Source of Funding

None.

9. Conflict of Interest

None.

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