World Applied Sciences Journal 38 (4): 302-308, 2020
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2020.302.308

The Composition and Role of Goat Milk in Lactose Intolerance - A Review

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Abstract: Goats are one of the main sources of milk and meat for human consumption. Goat milk is an important nutrient for humans, especially those who have a problem of lactose intolerance and sensitivity to cow milk. Goat milk is composed of fat, protein, lactose, vitamins, enzymes and mineral salts. Most of the components of Goat Milk are greater than that of other milk-producing animals. For instance, Goat Milk contains 25% more vitamin B_6, 47% more vitamin A and 13% more calcium than Cow Milk. However, available information concerning Goat Milk is mainly limited to data on its gross composition and information on the nutritional quality of Goat Milk especially important nutritional constituents are scarce. Even though Goat Milk is also used as a therapy against different problems including gastrointestinal disturbances, vomiting, colic, diarrhea, constipation and respiratory problem cultural beliefs challenge the reputation of the advantage of Goat milk consumption and the development of the sector, especially in developing countries. Therefore, community awareness creation on the composition and health benefits of Goat milk is substantial.

Key words: Goat Milk · Composition · Lactose Intolerance · Medicinal Value

INTRODUCTION

Goats are the earliest domesticated animals. As indicated by the archaeological evidence they have been associated with man in a symbiotic relationship for up to 10,000 years [1, 2]. Number of the individuals are maintained either as a source of income or as a hobby. Mostly goats are maintained as a source of the milk and were milked even before cows. Goat is also called a "Cow of the poor man". Many scientists focused on the functional properties of goat milk along with sheep milk. It is concluded that these milk have not only high nutritional value but also therapeutic value and dietary characteristics [3, 4].

Goat husbandry has been a part of agriculture since almost the first use of domestic animals and presently its popularity is increasing throughout the world and this increase is reflected a greater degree by the rise in the number of small herds maintained by individuals either as a source of income or as an avocation [5, 6]. Goats are an important component of the livestock industry having adaptability to harsh climates which make them suitable for landless and marginal farmers. Goats also play a vital role in the socio-economic structure of poor people who live in rural areas [7, 8].

Goats are present in all continents and the world total number of goats is 861.9 million. The largest number of goats is observed in Asia (514.4 million), followed by Africa (291.1 million), Northern America (3.0 million), Central America (9.0 million), Caribbean (3.9 million), South America (21.4 million), Europe (18.0 million) and Oceania (0.9 million) [9]. Goats are important milk producers in several parts of the tropics and contribute significantly to human nutrition in many developing countries [10, 11].

Goats produce only about 2% of the world's total annual milk supply [12, 13]. However, their global contribution to the nutritional and economic well-being of humanity is tremendous. There are nearly 500 breeds of goats in the world. However, only a half dozen is generally raised for their milk purpose and about 600-700 million dairy goats are present in the world [2, 3, 14].

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In Ethiopia, goats are raised mainly for three purposes. About 3% of adult goats are kept for milk, about 3.36% for meat, about 46.3% for breeding and the rest are raised for all the above three and other purposes [4, 11].

GM has advantages over a cow or human milk in having higher digestibility of protein and fat, alkalinity, buffering capacity and certain therapeutic values in medicine and human nutrition. In basic composition, GM has substantially higher protein and ash, but lower lactose than other species of milk. GM is somehow similar to CM in its basic composition. On average it contains total solids (12.2%), fat (3.8%), protein (3.5%), lactose (4.1%) and ash (0.8%). It has more fat, protein and ash and less lactose than CM. GM fat contains 97-99% free lipids of which about 97% is triglycerides and 1-3% bound lipids in which about 47% neutral and 53% polar lipids [15, 16]. The major carbohydrate of GM is lactose, which is about 0.2-0.5% less than in CM [4, 17, 18].

GM has higher calcium, phosphorus, potassium, magnesium and chlorine, but lower sodium and sulfur contents, than CM. The average mineral content of GM is higher than that of CM. It has a higher amount of vitamin A than CM. Besides, it is whiter than bovine milk; because goats convert all β-carotene into vitamin A in the milk. Due to their difference in composition and constituents, GM is much healthier than CM. There are many nutritional and medicinal values of GM. It is so highly nutritious that it can serve as a substitute for a meal. It is also preferred due to its low-fat content and its capability to neutralize the acids and toxins present in the body. The symptoms like gastrointestinal disturbances, vomiting, colic, diarrhea, constipation and respiratory problems can be eliminated when GM is fed to the infants [19-21].

Lactose is a sugar that naturally occurs in the milk from cows, goats and sheep. It is a disaccharide, which is 2 single sugar molecules (glucose and galactose) joined together. Lactose intolerance is caused by a deficiency in the lactase enzyme used to digest the milk sugar, lactose. In lactose intolerant individuals, unhydrolyzed lactose passes into the large intestine, where it is fermented by microbes that produce gases such as hydrogen, methane, carbon dioxide and short-chain fatty acids leading to gastrointestinal disturbances such as flatulence, abdominal pain and diarrhea [2, 20, 22]. Easier digestion of the GM allows the lactose to pass through the intestines more rapidly, not giving it time to ferment or cause an osmotic imbalance means there is no “leftover” lactose. Also, GM contains 10% less lactose than CM, most lactose-intolerant people can thrive on GM and its products [21, 23]. Therefore, the objective of this review is to highlight the composition and role of goat milk in lactose intolerance.

Composition of Goat Milk: Compositions of goat, cow and human milk are different and also vary with diet, breed, individuals, parity, season, feeding, management, environmental conditions, locality, stage of lactation and health status of the udder. GM contains protein, lipid, carbohydrate, vitamin and mineral [24].

Lipids: The fat content of GM across breeds ranges from 2.45 to 7.76%. The average diameters of fat globules for goat, cow, buffalo and sheep milk are reported as 3.49, 4.55, 5.92 and 3.30 ìm, respectively [3, 8, 25]. GM fat contains 97-99% free lipids (of which about 97% is triglycerides) and 1-3% bound lipids (about 47% neutral and 53% polar lipids) [5, 7, 16]. GM fat has significantly higher levels of short- and medium-chain-length fatty acids (MCT) (C4:0-C14:0) than cow and human milk. In GM the lipid globules are significantly smaller than in CM (“Natural homogenized”). In GM both a smaller diameter and the size distribution of globules have a larger proportion of smaller particles than in CM. A large number of fat globules with a small diameter make the GM more digestible. This is because the total surface area of the globules is very to effectively get in contact with the lipids [3, 26].

Proteins: There are five principal proteins in GM α-casein (α-CN), β-casein (β-CN), ê-casein (êCN), β-lactoglobulin (β-Lg) and α-lactalbumin (α-La) [5, 13, 27]. β-casein is the major casein fraction in GM, whereas α-casein is the major one in CM. Differences in amino acid composition between casein fractions of GM are much greater than differences between species (goat versus cow) [6, 28]. The more α-casein in milk the longer digestion, which depends on that α-casein is only partly digested by gastric juice enzymes. GM is a source of complete protein that contains all essential amino acids without the heavy fat content and mucus-producing components of CM [18, 29].

The most abundant amino acids are glutamate (plus glutamine, 20%), proline (10%) and leucine (10%). Among the three most abundant amino acids, goat and other non -primate milk contained greater glutamate and

proline and lower leucine than human milk. For sulfur-containing amino acids, cysteine is higher and while methionine is lowers in primate milk than in goat and other non-primate milk [11, 21, 30].

Carbohydrates: Lactose is the main carbohydrate in GM comprising about 4.4%. The lactose content of GM is about 0.2-0.5% less than in CM [3, 13]. Lactose is a disaccharide made up of glucose and a galactose molecule and is synthesized in the mammary gland. Lactose is a valuable nutrient because it favors intestinal absorption of calcium, magnesium and phosphorous and the utilization of vitamin D [15].

Lactose is the most important energy source during the first year of human life, providing almost half of the total energy required by infants [31]. Carbohydrates other than lactose found in GM are oligosaccharides, glycopeptides, glycol-proteins and nucleotide sugars in small amounts. GM is significantly rich in lactose-derived oligosaccharides compared to CM [32]. GM oligosaccharides have been shown to have anti-inflammatory effects in induced colitis [19, 33].

Minerals: Mineral content in GM is much higher than cow and human milk. It varies from 0.70% to 0.85%. GM is distinguished by its high chloride and potassium content. Iron bioavailability is higher in GM than in CM due to higher nucleotide content contributing to better absorption in the gut. Bioavailability for zinc was found higher in the case of human milk, lower values for sheep milk and average values for GM and CM. The average mineral content of GM is higher than that of CM. Concentrations of trace minerals are affected by diet, breed, animal and stages of lactation [4, 11, 34].

Vitamins: GM has a higher amount of vitamin A than CM. Caprine milk is whiter than bovine milk because goats convert all β-carotene into vitamin A in the milk. GM supplies adequate amounts of vitamin A and niacin and an excess of thiamin, riboflavin and pantothenate, for a child. Both goat and CM have low concentrations of vitamin B6 and vitamin D, which are both important during infancy [12, 18, 35]. Vitamin C is a well-known water-soluble antioxidant that is found in greater amounts in GM than in CM. This vitamin has been shown to affect many aspects of the immune system including the regulation of immunity via antiviral and anti-oxidant properties [36].

Table 1: The average composition of cow, goat and human milk (%)

Contents	Goat milk	Cow milk	Human milk
Fat	4.25	4.14	3.75
Protein	3.52	3.58	1.63
Lactose	4.27	4.96	6.98
Ash	0.86	0.71	0.21
Total solids	13.00	13.19	12.57
Solids not fat	7.75	9.25	8.82

Source: Yadav *et al*. [21]

Lactose Intolerance: Lactose intolerance (also known as lactase deficiency or milk intolerance), the inability of a person to effectively digest lactose, commonly called milk sugar. This inability to break down lactose is fundamentally caused by the lack (or insufficient amounts) of an enzyme normally found in the small intestine known as lactase. Lactose intolerance is sometimes seen in premature babies. Baby's body makes the enzyme lactase so they can digest milk including breast milk. In lactose intolerant individuals, unhydrolyzed lactose passes into the large intense, where it is fermented by microbes that produce gases such as hydrogen, methane, carbon dioxide and short-chain fatty acids leading to gastrointestinal disturbances [22, 37].

Types of Lactose Intolerance: Lactose intolerance can be categorized into four types [38].

Primary Lactose Intolerance: It is also called lactase non-persistence, which is the most common type of lactase deficiency. In people with this condition, lactase production declines over time. This decline often begins at about two years old. However, the decline may begin later. Children who have lactase deficiency may not experience symptoms of lactose intolerance until late adolescence or adulthood [31, 38, 39].

Secondary Lactose Intolerance: It results from injury to the small intestine. Infection, diseases, or other problems may injure the small intestine. Treating the underlying cause usually improves lactose tolerance [40].

Developmental Lactose Intolerance: It may occur in infants born prematurely. This condition usually lasts for only a short time after they are born. Lactase is deficient until at least 34 weeks gestation Up to 20% of dietary lactose may reach the colon in young infants and favor growth of probiotic bacteria may have a role in infantile colic undertake a 1-week empirical trial using lactase drops. It continues until 4 months of age, then weans off [41].

Congenital Lactose Intolerance: Is an extremely rare disorder in which the small intestine produces little or no lactase enzyme from birth. Genes inherited from parents cause this disorder [42].

Symptoms of Lactose Intolerance: Symptoms of lactose intolerance include abdominal pain, abdominal swelling (bloating) flatulence (excessive wind), diarrhea, Nausea, Gas and Cramping. Symptoms occur 30 minutes to 2 hours after consuming milk or milk products. Symptoms range from mild to severe based on the amount of lactose the person ate or drank and the amount a person can tolerate [31, 37, 38].

Role of Goat Milk in Lactose Intolerance: Since lactose intolerance is caused by milk, people should not avoid milk at all. The most popular milk is CM but if they got some allergens or sensitivity to CM, they must try some other alternatives like GM. Treatment with GM typically resolves between 30 and 40% of the problem [11, 43]. GM, as well as cow and human milk, contains lactose. Despite that many people with lactose intolerance do tolerate drinking GM. GM has demonstrated significant improvements in colic, minor digestive disorders, asthma and eczema over CM, as well as in infants and children with CM sensitize [6, 43].

Human milk has a more similarity with GM than CM which may be the reason for GM healing properties. Although, no food is better than mothers' milk at least for the first six months of life. The oligosaccharide profile of GM is most similar to that of human milk and the GM oligosaccharides could be included in infant formulas to improve the nutrition of infants. GM also resembles human milk in the protein structure. The major casein protein Beta casein found in both goat and human milk is different from the casein found in CM [44].

When comparing diets of goat and CM, the GM has improved digestive utilization of fat and protein and higher apparent digestibility coefficient and absorption of calcium, phosphorus, magnesium, iron, copper, zinc and selenium than that of a cow [7, 45]. The good metabolic utilization of several minerals in GM is suggested to be due to higher protein content, cysteine levels and amount of vitamin C and D compared to CM [5, 12, 46].

Anecdotal evidence suggests that GM is easier to digest due to the sour curd formed in the stomach as a result of the much lower content of a peculiar type of casein, αs-1 casein. The implication is that the different casein composing of GM allows the digestive products (Including lactose) to pass through the large intense more quickly and helps prevent the symptoms of lactose intolerance. GM is a natural alternative to CM and can often a great alternative for people who have sensitivity [4, 20, 23].

Fat globules in GM are smaller than in CM. This smaller size, combined with the lack of agglutinin, a protein that causes fat molecules to clump together and which is present in CM, has several implications. It is theorized that the smaller fat globule size, combined with the fact that the globules do not clump together as in CM, also contribute to the higher digestibility of GM and the better tolerance of it for individuals with certain digestive disorders. The size of the fat globules also affects the digestibility since it provides better dispersion and a more homogenous mixture of fat. The large total surface area of the globules makes it easier for enzymes to reach and get in contact with the lipids [17, 47].

GM has a lower carbohydrate level, almost all of which is due to less lactose in the milk. The inability to digest lactose is a common condition and milk with less lactose is helpful for those individuals. GM is much higher in short-chain fatty acids and medium-chain fatty acids than CM. These short-chain fatty acids and medium-chain fatty acids have a larger surface-to-volume ratio and are better digested and absorbed than the long-chain fatty acids prevalent in CM [20, 48]. GM contains a percentage of proteins with different structures than CM proteins. These differences enhance the digestibility of GM protein and cause fewer allergenic reactions like CM allergy. GM, like human milk, contains low levels (89% less than CM) of alpha αs1 casein and high levels of alpha αs2 casein, which is non-allergic [33].

Treatment of Lactose Intolerance: Most people with lactose intolerance can tolerate some amount of lactose in their diet and do not need to avoid milk or milk products completely. Avoiding milk and milk products altogether may cause people to take in less calcium and vitamin D than they need. Since GM has a smaller amount of lactose level and high digestibility than CM it is used as an alternative or treatment of lactose intolerance.GM is more completely and easily absorbed than CM leaving less undigested residue behind in the colon to ferment and eliminate the uncomfortable symptoms of lactose intolerance [11, 43].

Lactic acid bacteria are often used as probiotic starter culture and health effects from those associated with increased lactose intolerance [20]. Other than GM people with lactose intolerance are also more likely to tolerate yogurt than milk, even though yogurt and milk have

similar amounts of lactose. Supplementation with probiotics, in addition to consuming yogurt that has been enhanced with certain types of bacteria, can alleviate symptoms of lactose intolerance by modifying the metabolic activity of microbiota in the colon. Similarly, butter and cream contain very low levels of lactose and are well tolerated [38].

CONCLUSION AND RECOMMENDATIONS

The unique characteristic of GM has been fairly surveyed regarding the nutritional value and some health effects. It is well known that GM has high nutritional value than other species of animals, where there are adequate browse and water supply and they are mainly raised in rangelands in semi-deserts and subtropical conditions. A goat can produce the milk of good composition and quality for human consumption. These compositions of milk are fat, protein, ash, vitamins, lactose and enzymes. GM has high digestibility and less fat and protein content which reduces digestive disorders and allergic reactions. In conclusion, community awareness on the composition, nutritional and medicinal values and its role in lactose intolerance is paramount important.

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