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Hisham Mahaboob C
Department of Food Technology and Nutritional, School of Agriculture, Lovely Professional University, Punjab, India

Corresponding Author:
Hisham Mahaboob C
Department of Food Technology and Nutritional, School of Agriculture, Lovely Professional University, Punjab, India

Studies on the effects of replacement of cow milk by goat milk in different dairy products

Hisham Mahaboob C

Abstract
The goat is one of the most important dairy contributor and accounting for roughly 2% of the world's total yearly milk output. In many other regions of the globe, goat's milk is the most widely consumed milk, and it is both delicious and healthy. Goat milk has fewer fat globules, making it more easily digested. Polyunsaturated fatty acids in goat milk fat are primarily responsible for goat milk's anti-cancerous activity. Although goat milk protein is somewhat lower than cow milk protein, goat milk protein is more digestible than cow milk protein. Taurine, found in goat milk, is said to have a protective effect against cardiovascular disease and hypertension, as well as assisting in the synthesis of vital amino acids. It contains readily absorbed vitamins, minerals, trace elements, electrolytes, enzymes, proteins, and fatty acids. Goat's milk has a resemblance to human milk that is unmatched in bovine (cow) milk, as well as a number of therapeutic properties. As a result, public knowledge of the benefits of drinking goat milk should be promoted in order to increase goat milk production and use.

Keywords: Cow milk, goat milk, dairy products

Introduction
Goat is truly known as poor man’s cow. Dairy goat and dairy sheep farming are important parts of many nations' economies, notably in the Mediterranean and Middle East, and are particularly well organised in France, Italy, Spain, and Greece (Miller and Lu, 2019) [30]. India now has 126 million goats, accounting for 14.5 percent of the world's total (FAO, 2009) [13]. The goat, more than any other mammalian farm animal, is one of the most important producers of dairy and meat products to rural populations, particularly in developing countries (Kumar *et al*., 2012) [20]. Home consumption is one of the most significant components of goat milk demand. Because of the expanding population, this need is increasing and in numerous established and emerging nations, connoisseur interest in goat milk products, particularly cheeses and yoghurt, is the second significant component of demand for goat milk. Because of the rising levels of per capita income, this need is expanding. Furthermore, a significant portion of the demand for goat milk derives from those who suffer from cow milk allergies and other gastro-intestinal problems. This demand is also increasing as individuals become more aware of the difficulties with standard medical treatments for such illnesses. People of all socioeconomic levels desire or require goat milk. Despite the far higher amount of cow milk available, the production of goat milk and its products is often significantly cheaper, resulting in a lower market price. As a result, goat milk production and marketing are a key niche in the entire dairy industry sector. Goat milk has greater digestibility, alkalinity, buffering capacity, and some therapeutic benefits in medicine and human nutrition than cow or human milk (Kumar *et al*., 2012) [21].

From a nutritional, immunological, and food safety standpoint, human milk is regarded nature's best new-born nourishment. Time limitations, health problems, and urbanisation, on the other hand, may lead to the termination of breastfeeding (Kumar *et al*., 2016) [20]. As a result, there is a need to provide an alternative feeding method for infants who are unable to breastfeed. Goat milk has been proposed as a viable substitute for cow and human milk (Zenebe *et al*. 2014) [41]. Goat milk has fewer fat globules, making it more easily digested. Polyunsaturated fatty acids in goat milk fat are primarily responsible for goat milk's anti-cancerous activity (Kumar *et al*., 2016) [20]. Taurine (2-aminoethanesulfonic acid), found in goat milk, is said to have a protective effect against cardiovascular disease and hypertension, as well as assisting in the synthesis of vital amino acids (Schaffer and kim, 2018) [36]. Goat milk has a higher mineral and vitamin content than cow milk, as well as a better bioavailability in the human gut (Lad *et al*., 2017) [22].

People suffering from lactose intolerance patients will benefit from goat's milk since it has less lactose content than cow's milk. Furthermore, higher selenium content in goat milk results in blood platelet regeneration which will people suffering from dengue fever (Mahendru *et al*., 2011) [28]. Antioxidant and antibacterial peptides have been found to be produced by bioactive peptides released during fermentation and *in vitro* digestion of goat milk (Kumar *et al*., 2016) [20]. Goat milk (caprine milk) contains sialic acid, which has been shown to aid in rapid brain development (De Sousa *et al*., 2015) [10]. When compared to the milk of other dairy animals, goat milk offers a lot of promise for illness prevention (Lima *et al*., 2017) [26]. Goat milk has pottential nutraceutical properties, making it ideal for new-borns, the elderly, and those who are recovering from illness (Kumar *et al*. 2016) [20]. The relationship between the structural and functional features of goat milk and its usage in preening and decreasing these frequent milk-based health problems has been clarified by recent scientific data (Kumar *et al*., 2016) [20]. Goat milk is a great dairy alternative that has the potential to replace traditional dairy products while also improving human health, particularly for those with lactose sensitivity (Kumar *et al*., 2012) [21].

Nutritional Profile of Goat Milk

The nutritional and health advantages of goat milk are linked to a variety of medical issues, the most common of which is food allergies, with goat and cow milk proteins being the most common culprit and that is because α-lactoglobulin isn't found in human milk, it's been thought that it's the most allergenic protein in goat and cow milk, however, comparative studies found no difference in allergenicity between α-lactoglobulin and caseins (Layman *et al*., 2018) [24]. Cow milk allergy is a common disease in children under the age of three, with a prevalence of 2.5% in the first three years of life, occurring in 12-30% of infants under the age of three months, with an overall prevalence of 7-8% in Scandinavia, even as high as 20% in some areas and reported in Italy in 3% of children under the age of two (Kumar *et al*., 2012) [21]. The various caseins and whey proteins have a broad range of genetic polymorphisms, which adds to the complexity of the cow milk allergy issue and makes it difficult to establish which protein is primarily responsible for an allergic reaction (Hochwallner *et al*., 2014) [17]. However, if genetic polymorphisms of milk proteins are explicitly utilized for clinical testing, this genetic protein variation may actually assist determine which protein is the allergen (Kumar *et al*., 2012) [21]. Goat milk with little or no αs1-casein but high αs2-casein has lower curd production, longer rennet coagulation time, higher heat stability, and weaker curd hardness, which might explain the advantages in human digestive tract digestibility (Park, 2017) [33]. During a 5-month study, 38 youngsters were given goat milk as a replacement for cow milk. Weight increase, height, bone mineralization, and blood serum Vitamin A, calcium, thiamine, riboflavin, niacin, and haemoglobin content were all higher in goat milk-fed children than in cow milk-fed children (Kumar *et al*., 2012) [21].

Table 1: Proximate Composition (%) of Goat, Cow and Human Milk

	Goat	Cow	Human
Moisture	87.00	87.20	87.43
Fat	4.25	3.70	3.75
Protein	3.52	3.50	1.63
Lactose	4.1	4.7	6.98
Ash	0.86	0.70	0.21
Solid not fat	8.75	9.10	8.82
Total solid	13.00	12.80	12.75
Casein	2.4	3.0	0.3-0.5
αs1-casein	5.6	39.7	00
αs2-casein	19.2	10.3	00
β-Casein	54.8	32.7	60-70
κ-Casein	20.4	11.6	20-30

Source: Park *et al*., 2007 [35], Albenzio *et al*., 2010 [3], Balthazar *et al*., 2017 [4]

Protein Content of Goat Milk

Goat milk has a protein content that is nearly equal to cow milk. The composition of goat milk's individual constituents, such as high levels of casein and the structure of the casein micelle, a wide range of bioactive peptides within these fractions, as well as minor proteins and the non-protein fraction, which includes amino acids, nucleotides, and nucleosides, distinguishes the protein (Turkmen, 2017) [42]. Many of goat milk's physical qualities and health advantages are determined by its protein composition. *In vitro*, trypsin completely hydrolyzed 96% of goat casein compared to approximately 76-90% of cow casein. Similarly, human gastric and duodenal fluids breakdown goat milk far faster than cow milk (Kumar *et al*., 2016) [20]. Also goat milk has a greater dye-binding capacity per unit protein (1% higher than cow milk) and lower infrared absorption (4% lower than cow milk), separate calibration curves must be used to assess milk protein content for each species (Kumar *et al*., 2012) [21]. Goat milk proteins are comparable to major cow milk proteins in terms of broad categories such as α-, β-, κ-caseins, β-lactoglobulin, and α-lactalbumin, but they differ significantly in terms of genetic polymorphisms and frequency in goat populations. Casein in milk is made up of 80% caseins and 20% whey proteins. αs1 casein, αs2 casein, β Caseins, and k caseins are the main caseins found in goat and cow milk (Atanasova and Ivanova 2010) [3]. Caseins formed by action of chymosin on k casein during milk clotting process of cheese making are excellent source of anti-thrombotic peptide (Atanasova and Ivanova 2010; Kumar *et al*., 2012) [3, 21]. The size of the casein micelle and the low amount of s1 casein are two of the most distinctive characteristics of goat milk. Goat milk casein micelles are bigger than cow milk casein micelles, ranging from 100 to 200 nm vs 60 to 80 nm in cow milk (Silanikove *et al*. 2010; Ingham *et al*., 2018) [38, 18].

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

	Goat Milk	Cow Milk
Essential Amino Acid		
Threonine	0.138	0.115
Isoleucine	0.160	0.128
Leucine	0.341	0.266
Lysine	0.342	0.252
Methionine	0.077	0.071
Cystine	0.030	0.023
Phenylalanine	0.175	0.133
Tyrosine	0.162	0.159
valine	0.210	0.147
Total	1.639	1.298
Non-Essential Amino Acid		
Arginine	0.135	0.114
Histidine	0.122	0.093
Aspartic acid	0.177	0.960
Alanine	0.250	0.214
Glutamic acid	0.694	0.554
Glycine	0.055	0.049
Proline	0.310	0.253
Serine	0.152	0.147
Total	1.840	1.522

Source: Ceballos *et al*., 2009 [9]; Lima *et al*., 2017 [26]

Fat Content of Goat Milk

The fat or lipid content of goat milk is an essential component. In both cow and goat milk, fat globules range in size from 1 to 10 micron. In goat milk, however, the percentage of globules smaller than 5 microns is 83%, compared to 62% in cow's milk (Bihaqi and Jalal, 2010) [7]. The fatty acid profile of average goat milk fat differs significantly from that of average cow milk fat, with much higher levels of butyric (C4:0), caproic (C6:0), caprylic (C8:0), capric (C10:0), lauric (C12:0), myristic (C14:0), palmitic (C16:0), linoleic (C18:2), but lower levels of stearic (C18:0) and oleic acid (C18:1) (Kompan and Komprej, 2012). Because of their unique properties, capric, caprylic, and medium chain triglycerides (MCT) have become established medical treatments for a variety of clinical disorders, including malabsorption syndromes, chyluria, steatorrhea, hyperlipoproteinemia, intestinal resection, premature infant feeding, non-thriftiness in children, infant malnutrition, epilepsy, cystic fibrosis, coronary by-pass, and gallstones (Kumar *et al*., 2012) [21]. Goat milk has more monounsaturated fatty acid (MUFA), polyunsaturated fatty acid (PUFA), and medium chain triglycerides (MCT) than cow milk, all of which have been shown to benefit human health, particularly cardiovascular diseases (Lima *et al*., 2017) [26]

Table 3: The average fatty acid composition (g/100 g) in lipid of goat milk compared to cow milk

Fatty Acid	Goat Milk	Cow Milk
Butyric acid (C4:0)	0.13	0.11
Caproic acid (C6:0)	0.09	0.06
Caprylic acid (C8:0)	0.10	0.08
Capric acid (C10:0)	0.26	0.08
Lauric acid (C12:0)	0.12	0.09
Myristic acid (C14:0)	0.32	0.34
Palmitic acid (C16:0)	0.91	0.81
Stearic acid (C16:0)	0.44	0.40
Total medium chain triglyceride (C6-14)	0.89	0.61
Total saturated fatty acid (C4-18)	2.67	2.08
Palmitoleic acid (C16:1)	0.08	0.08
Oleic acid (C18:1)	0.98	0.84
Total mono unsaturated fatty acid (C16:1-22:1)	1.11	0.96
Linoleic acid (C18:2)	0.11	0.08
Linolenic acid (C18:3)	0.04	0.05
Total poly unsaturated fatty acid (C18:2-18:3)	0.15	0.12

Source: Nunez-Sanchez *et al*. 2016 [43]; Bernard *et al*., 2018 [6]; Hageman *et al*., 2019 [15]

Goat Milk for the Treatment of Dengue Fever

Selenium (Se) is also known as selenoprotein and is one of the most important micronutrients. It is found in approximately 25 proteins. Selenoproteins are mostly enzymes that protect cells from cellular damage induced by the creation of by-products of oxygen metabolism due to their antioxidant properties (Mahendru *et al*., 2011) [28]. When compared to cow milk, goat milk contains more than 27% selenium (Belewu and Adewole 2009) [5]. Selenium deficiency causes a drop in platelet count in the body, which is the major symptom of dengue fever. Dengue fever is spread by infected mosquitos that carry the virus. These fever-causing viruses are transmitted to humans by mosquito bites. These viruses enter the body through the bloodstream and grow in the glands, contaminating the remaining organs and tissues. The major symptom of dengue fever is a drop in platelet count and because external sources of platelets are unavailable, goat milk is commonly given to maintain body fluid balance in dengue patients. Consumption of goat milk increases biliary cholesterol secretion, lowering plasma cholesterol levels, although phospholipids, biliary acid, and lithogenic levels remain unchanged (Lopez-Aliaga *et al*., 2010) [27]. In addition, shortage causes irreparable cardiomyopathy (Morgan *et al*. 2010) [31].

Goat Milk in Lactose Intolerance

Lactase is a protein that breaks down lactose, milk's major carbohydrate. Lactase is an enzyme that converts lactose to glucose and galactose and is generated by the microvillus membrane of enterocytes (Hammer and Hammer 2012) [16]. Undigested lactose can cause gastrointestinal problems such bloating, abdominal discomfort, and diarrhoea if lactase activity is inadequate or absent. Lactase deficiency is most commonly caused by the genetically or age-related downregulation of lactase activity in babies and the elderly. Although symptoms have been reported after consuming less than 6 g of lactose, most people can handle 12 g of lactose in a single dosage of milk (about 250 ml) with no or moderate

side effects (EFSA 2010). When given in smaller doses throughout the day, higher amounts can be tolerated. Consumption of lactase-active yoghurts and fermented items that aid lactose digestion, as well as the usage of low-lactose milks are both beneficial. Goat milk has less lactose than cow milk, thus it can be used to avoid lactose intolerance symptoms (Kumar *et al*., 2016) [20].

Goat Milk as Source Antioxidant peptides

Researchers are especially interested in antioxidant peptides because they have the ability to prevent or slow oxidative degradation of foods, hence extending shelf life (Kumar *et al*., 2016) [20]. In-vitro hydrolysis by enzymes or fermentation by lactic acid bacteria can produce strong antioxidant peptides from goat milk proteins (Ahmed *et al*. 2015) [1]. These antioxidant peptides have strong radical scavenging, iron chelation, and polyunsaturated fatty acid autooxidation inhibitory properties (Gobba *et al*. 2014) [14]. In a goat's milk casein hydrolysate produced with Alcalase and Pronase, five antioxidant peptides were discovered and they were VYPF (Val-Tyr-Pro-Phe), FPYCAP (Phe-Pro-Tyr-Cys-Ala-Pro), FGGMAH (Phe-Gly-Gly-Met-Ala-His), YPPYETY (Tyr-Pro-Pro-Tyr-Glu-Thr-Tyr) and YVPEPF (Tyr-Val-Pro-Glu-Pro-Phe) (Li *et al*., 2013) [25].

Goat Milk as Antimicrobial Agent

The milk proteins found in goat milk are the primary source of bioactive peptides (Selvaggi *et al*., 2014) [37]. During meal digestion and processing on the gastrointestinal tract, a bioactive peptide from milk protein was activated and released via the proteolysis enzymatic process. Goat milk oligosaccharides operate as scavenger receptors for a variety of pathogens, as an inhibitor of Escherichia coli heat-stable enterotoxin, and in preventing leukocyte-endothelial cell contact, all of which contribute to an anti-inflammatory effect (Boehm and Stahl, 2007) [8]. Antimicrobial action of medium chain fatty acids against gram–negative bacteria has been discovered (Van-Immerseel *et al*. 2004) [40]. Pepsin, a stomach enzyme, breaks down goat milk into peptides that are antibacterial against gramme negative bacteria (Park, 2009) [34]. Fermented goat milk, like fermented cow milk, has antibacterial action against Serratia marcesens (Slacanac *et al*. 2010).

Goat Milk as Prebiotics

Milk contains non-digestible carbohydrates called oligosaccharides, which can function as a prebiotic and these prebiotics promote the growth of helpful gut bacteria while inhibiting the growth of harmful bacteria, which helps to maintain the health of the gastrointestinal system and because of their prebiotic and anti-infective effects, oligosaccharides are considered helpful components of human milk (Boehm and Stahl 2007) [8]. Because the majority of oligosaccharides in human milk (more than 95 percent) are resistant to digestion, their primary target is the neonate's gastrointestinal tract. Goat milk generally contains 250 to 300 mg/L oligosaccharides, which is about 4-5 times more than cow milk (75-100 mg/L) (Martinez-Ferez *et al*. 2005) [29]. The oligosaccharides present in goat's milk have been demonstrated to help animals recover from colitis by reducing intestinal inflammation (Lara-Villoslada *et al*. 2006) [23].

Conclusion

In terms of nutritional content of milk, goat milk clearly outperforms cow milk, as evidenced by this research. It is necessary to raise public awareness about the benefits of drinking goat milk in order to increase goat milk production and consumption. Goat milk has a high bioavailability of proteins, lipids, vitamins, and minerals, making it ideal for baby meals. Goat milk should be encouraged in developing nations like India, where malnutrition and illnesses are more widespread, as well as high poverty levels, due to its high nutritional content and physiological characteristics. Dairy goats have minimal maintenance, general administration, and feeding costs. However, in poor nations, goat milk is still underutilised and commercialised. And there is a scarcity of information on its commercialization in the scientific community. More study is needed to fully utilise the use of liquid goat milk in the production of a variety of milk products, particularly cheeses and fermented milk foods, all over the world.

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