Int.J.Curr.Microbiol.App.Sci (2020) *9*(10): 2750-2764

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 9 Number 10 (2020)**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2020.910.332

Overview of Functionality of Goat and Sheep Milk

A. J. Pandya, A. J. Gokhale* and J. M. Mallik

Department of Dairy Processing & Operations, Faculty of Dairy Science, Anand Agricultural University, Anand 388 110, India

**Corresponding author*

Keywords

Functionality, Goat and Sheep milk, α-lactoalbumins and β- lactoglobulin

Article Info

Accepted:
20 September 2020
Available Online:
10 October 2020

A B S T R A C T

Small ruminant milks have composition different from cow milk. Goat and Sheep milks are natural functional milks mainly because of its high nutritional value, digestibility and therapeutic and dietary characteristics. Goat's milk also contains more free amino acids, minerals (calcium, magnesium, potassium and phosphorus, selenium) and vitamins than cow's milk which are essential for bone growth and the proper development of newborns. In the whey protein content about 55% of all milk whey proteins are albumins, which include α-lactoalbumins and β- lactoglobulin, a rich source of bioactive peptides with extra physiological activity. Goat and Sheep milk is a good source of conjugated linoleic acid and α-linolenic acid. It is claimed to inhibit the occurrence and development of cancer, in the prevention of coronary heart disease and atherosclerosis, inhibits the development of osteoporosis and stimulates the immune system.

Introduction

Functional milk is milk that provides health benefits beyond what regular milk provides. It has its origin in functional foods. British Nutrition Foundation defines functional foods as "foods with health-promoting benefits and/or disease – preventing properties over and above their usual nutritional values". Functional foods are foods or food ingredients that provide a health benefit beyond basic nutrition. These foods have a potentially beneficial effect on an individual's health when it is consumed as part of a varied diet and on a regular basis at effective levels."

Many scientists working on the functional properties of goat and sheep have concluded that these milks are natural functional milks mainly because of its high nutritional value, digestibility and therapeutic and dietary characteristics. Among these compounds are bioactive peptides and lipids, such as conjugated linoleic acids and other bioactive components like hormones, cytokines, oligosaccharides, nucleotides and minor components, which may have an important role on the development and maintenance of metabolic, immunological and physiological processes and thus contribute to the development of functional dairy products (Haenlein, 2004; Raynal-Ljutovac *et al*., 2008, Salva *et al*., 2010, Salva *et al*., 2011).

Milk and colostrum contain a great number of bioactive components influencing the human health such as weight management and hypertension. Furthermore, milk components, such as calcium and proteins and new structures created by reaction of these with other components have a great influence on the technological properties of the milk, and might also influence digestion and health properties. Since Goat and sheep milk is richer in such milk components compared to bovine milk, it is justifiable to consider goat and sheep milk to be natural functional milks (Assis *et al*., 2016).

Goat and sheep milk

Goats and sheeps seem to be the earliest domesticated animals and, due to their inherent nature, they have been raised usually in small herds maintained by individuals either as a source of income or as a hobby. They have been raised for milk for thousands of years and were milked even before cows. Nevertheless, as pointed out in the literature, goats have provided important sustenance, self-sufficiency, and survival for people and countries during economically difficult times. Although the goat nickname “cow of the poor man” still persists in some countries, there is a new consensus in the world that dairy goats provide foods not only for starving and poor people but also for prosperous periods and affluent people (Haenlein, 1996).

Nearly 60% of the world’s goats are found in Asia, with China, India, Pakistan and Bangladesh having the highest populations. Although most income from global goat production comes from meat sales, there has been a simultaneous increase in goat milk production and consumption. Total global goat milk production was estimated at 18.7 million tonnes in 2017. It increased 62% from 1993 to 2013. From just 2007 to 2017, production increased by 16%. During the past decade, Asia has seen the largest increase in goat milk production by 22%, followed by Africa 13%, Oceania 9%, Americas 5%, and Europe 4% (Bath and Christopher, 2019).

Sheep and goat milk represented only 1.3 and 1.9%, respectively, of the world's total milk production in 2018. According to the FAO (2018) world total goat milk production was 15.26 million metric tons per annum, while Sheep Milk Production was 10.37 million metric tons per annum. The top producers of goat milk in 2018 were India (5.75 million metric tons), 25 percent of global goat milk production and 3.5 percent of national milk production. Top producers of Sheep milk were China (1.54 million metric tons), followed by Turkey and Greece (1.10 and 0.7 million metric tons) and other Mediterranean countries (Statista, 2020).

Dairy goat generally produce between about 1100 kg of milk in 280 days lactation period, while sheep produce about 350 kg in 245 days lactation period which much lower as compared to dairy cows with 8500 kg in 305 days lactation period (British Dairy Sheep Association, 2006).

Growing health awareness is a driving force to look for food products that have a beneficial effect on human body. Goat milk is as close to a perfect food as possible in nature and its chemical structure is amazingly similar to mother's milk. For this reason, in some countries it is used as the basis for the development of infant formula in place of cow milk.

Chemical composition

Goat and sheep milk is white in colour as compared to cow milk, which is yellowish due to the presence of carotene and goats convert all carotene into Vitamin A in the milk, hence is higher in content compared to cow milk and comparable to human milk content of Vitamin A. Goat milk has a stronger flavour than sheep milk, which is due to liberation of short chain fatty acids which imparts goaty smell. Unlike cow milk, which is slight acidic, goat milk is alkaline in nature, which is very useful for people with acidity problems. This alkalinity is due to the higher protein content and different arrangement of phosphates.

The high nutritive value of goat and sheep milk is associated with its chemical composition. As evident from the Table 1 the chemical composition of goat milk is similar to cow milk with the main difference in protein and fat structure while sheep milk has higher fat, protein and lactose content.

The differences in gross composition of goat and sheep milk make the rennet coagulation time for sheep milk shorter and the curd firmer owing to the differences in the casein composition and content (Tamime *et al*., 2011).

Functional ingredients: Milk protein

The richest source of functional milk components is protein. In human nutrition, it mainly serves the nutritional function as it provides non-essential amino acids and nitrogen for the synthesis of body proteins and amino acids (Haenlein, 2002). Goat milk proteins have a high value because they contain all non-essential amino acids. The content of non-essential amino acids varies according to the protein fraction. Whey proteins are rich mainly in lysine, threonine, isoleucine and valine. Alpha- lactoalbumin, with the highest biological value, has relatively large amounts of cystine and tryptophan.

Casein in milk occurs as the precursor of caseinogen. It is a complex heterogeneous protein. The main fractions are α_{S1}, α_{S2}, β and κ-casein. The proportion of casein in milk is estimated to be about 2.12% and constitutes 75-85% of all proteins. It was that about 60% of allergic reactions in humans are caused by the principal milk protein and lactoglobulin. The most allergenic is the casein fraction αS1, the content of which in goat milk is very small unlike in cow milk, in which it forms about 33% of all caseins.

About 100 g of total casein contains 5.6 g of the α_{S1} fraction in goat milk compared to 38 g in cow milk. For this reason children with protein intolerance cannot consume cow milk due to the risk of allergic disorders. Small amounts of the α_{S1} casein fraction and the small size of casein micelles cause goat milk to be rapidly digested by proteolytic enzymes of the stomach, as a result of which goat milk is also recommended for people with gastrointestinal problems, especially ulcerations (Krzyzewski *et al*., 2002).

κ- Casein was also shown to have antithrombotic properties as it inhibits platelet and serotonin secretion. Many bioactive peptides, released during enzymatic digestion, were identified in sequences of casein (Bernacka, 2005).

In studies with rats, which had malabsorption syndromes, it was found that goat milk improved the intestinal absorption of copper, which was attributed to the higher contents of cysteine (derived from cystine) in goat milk (83 mg/100 g) than in cow milk (28 mg/100 g) (Barrionuevo *et al*., 2002).

The genetic polymorphism that occurs in the proteins between the different species is what clarifies the potential use of goat's milk as a substitute to cow's milk when allergic disease is present. It has been reported that 40–100% of allergic patients, sensitive to cow's milk proteins, are able to tolerate goat's milk proteins (Ballabio *et al*., 2011, Haenlein, 2004) (Table 2–4).

Average amino acid composition of goat and cow milk (Table 8) shows higher levels of 6 of the 10 essential amino acids: threonine, isoleucine, lysine, cystine, tyrosine, valine in goat milk. Their comparative metabolic effects have not been studied much in goat milk, but this could aid in the interpretation of some of the empirical beneficial effects of goat milk in human nutrition.

The higher digestibility and absorption of goat milk is mainly associated with the content of whey proteins. Whey proteins account for 0.6-0.7% of milk and show beneficial nutritive, physiological and functional properties. Unlike casein, they contain no phosphorus and are characterized by a high content of sulfur amino acids, mainly methionine and cystine. About 75% of all milk whey proteins are albumins, which include α-lactoalbumins and α-lactoglobulins, a rich source of bioactive peptides with extra physiological activity. Other whey proteins are lactoferrin, lactoperoxidase, immunoglobulins, glycomacropeptide, and various growth factors.

One of the functional components of goat milk is alpha-lactalbumin (α-La). Forming about 21% of all proteins, it serves different functions in the body: it is a calcium carrier and it can bind other metals such as magnesium, cobalt and zinc. In addition, it acts as an immune factor (which is particularly important in infant feeding) and has an anti-cancer effect.

Another whey protein with functional properties is beta-lactoglobulin (β-Lg). It forms the largest part of all whey proteins in milk (54%). Because of a high methionine content, α- LG provides protection against cancer development. It is a carrier of retinol, which is essential for the normal development of infants and for the vision process. Other functions performed by beta-lactoglobulin in the body are the ability to bind fatty acids, as well as antioxidant properties (by binding Cu and Fe ions, it inhibits the oxidation of milk fat). It must be remembered, however, that beta-lactoglobulin is an antigenic protein and can therefore induce allergy (this protein is not found in a woman's milk).

Lactoferrins (Lf) are a group of biologically active milk proteins with functional properties. Lactoferrin shows a high affinity to Fe, especially one of the forms known as hololactoferrin. It is characterized by high thermal stability in both acid and neutral environments. It also takes part in the transport of Ca, Cu, Mn, Zn and Al. Because of its antioxidant properties, it prevents the formation of free radicals. As an immune factor, it stimulates the immune system, and has anti-inflammatory and bacteriostatic properties. It is an anticancer agent that inhibits the binding of neoplastic growth factors, thus preventing the development of cancer and inhibiting the development of Alzheimer disease (Mohamed and Mohamed 2011, Francesco *et al*., 2016).

Functional ingredients: Milk fat

The quality and nutritive value of animal products is subject to constant evaluation and review, if only due to the high proportion and unfavorable composition of animal fats, mainly the high proportion of saturated acids and the insufficient proportion of unsaturated acids, especially essential unsaturated fatty acids (EUFA). According to FAO recommendations, with the desired 30% proportion of fat energy in total energy of the human diet, one-third of this energy should be from saturated fatty acids (SFA), over one-third from monounsaturated fatty acids (MUFA), and less than one-third from polyunsaturated fatty acids (PUFA) (Jelinska M., 2005).

Levels of the metabolically valuable short and medium chain fatty acids, caproic (C6:0) (2.9%, 2.4%, 1.6%), caprylic (C8:0) (2.6%, 2.7%, 1.3%), capric (C10:0) (7.8%, 10.0%, 3.0%), and lauric (C12:0) (4.4%, 5.0%, 3.1%) are significantly higher in sheep and goat than in cow milk (Park *et. al*., 2007).

Goat milk exceeds cow milk in monounsaturated (MUFA), polyunsaturated fatty acids (PUFA), and medium chain triglycerides (MCT) (Table 5), which all are known to be beneficial for human health, especially for cardiovascular conditions and has great potential in justifying the uniqueness of goat milk in human nutrition and medicine (Haenlein, 1992) for treating the various gastro-intestinal disorders and diseases, besides its value in alleviating cow milk allergies.

Excessive consumption of SFA causes a number of metabolic disorders, resulting in many diseases such as obesity, atherosclerosis, cholelithiasis, diabetes, and cancer, especially cancer of the colon and prostate cancer. Of the long-chain fatty acids in milk, PUFA are the most valuable for consumers because of their anticancer, antiatherosclerotic, hypotensive, antibacterial and immune-boosting properties. Of great significance are families of PUFA acids: linoleic C18:2, n-6 and α-linolenic C18:3, n-3.

None of these acids is synthesized in the human body, although they can be converted within families. Their metabolites are precursors of eicosanoids: prostaglandins, thromboxanes and leukotrienes, the hormones that serve many regulatory functions in the body (Reklewska *et al.*, 2002).

The quality of fat is largely determined by the content of individual fatty acids. The profile of fatty acids is more beneficial in goat milk compared to sheep and bovine milk because of the UFA/SFA ratio of 0.56 vs. 0.37. Average goat milk fat differs in contents of its fatty acids significantly from average cow milk fat (Jenness, 1980), being much higher in 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 in stearic (C18:0), and oleic acid (C18:1). Three of the MCT (C6–C10) have actually been named after goats, because of their predominance in goat milk.

Capric, caprylic acids and MCT have become established medical treatments for an array of clinical disorders, including malabsorption syndromes, chyluria, steatorrhea, hyper-lipoproteinemia, intestinal resection, premature infant feeding, non-thriftiness of children, infant malnutrition, epilepsy, cystic fibrosis, coronary by-pass, and gallstones, because of their unique metabolic ability to provide direct energy instead of being deposited in adipose tissues, and because of their actions of lowering serum cholesterol, inhibiting and limiting cholesterol deposition (Alferez *et al*., 2001).

Goat milk (100 g) contains about 25 mg of Conjugated linoleic acid (CLA), which is also known as rumenic acid, and is formed as a result of enzymatic reactions by Butyrivibrio fibrisolvens symbiotic bacteria found in the rumen of ruminants. Mono-gastric animals are less capable of producing CLA (Jahreis *et al*., 1996).

Research on the role of conjugated dienes of linoleic acid showed that they inhibit the incidence and growth of cancer in animals and humans, among others by preventing the proliferation of malignant melanoma, and colon, lung and breast cancer. CLA was also shown to prevent osteoporosis and atherosclerosis, to increase immunity and to reduce fatty tissue. The conjugated diene of linoleic acid is undoubtedly a functional component of goat milk fat (Basu *et al*., 2000, Ip *et al*., 1999, Cossignani *et al*., 2014).

Another important component of the human diet in addition to conjugated linoleic acid is the cholesterol content of food products. Current recommendations suggest that daily consumption of cholesterol should not exceed 300 mg. Research (Alferez *et al*., 2001, Haenlein, 2004) has shown that 100 ml of goat milk contains from 12 to 17 mg of cholesterol, which is almost half of that in sheep milk (Table 6). Although it has various positive roles in the body by contributing to the formation of hormones, bile acids, vitamin D3 and other compounds, cholesterol may be hazardous to the health and even life of humans as it often causes the atherosclerosis of vital arteries. Cholesterol found in dairy products is fairly resistant to auto-oxidation processes, which is due, among others, to the low content of Fe and Cu that act as pro-oxidants and to the saturated fatty acid environment. Total concentration in the blood largely depends on the content of some saturated fatty acids, as evidenced by positive correlations between these milk components (Haenlein, 2006).

Carbohydrates

The major carbohydrate of milk is termed as lactose and is found in varying concentrations in the milk of all mammals except for seals. Lactose is a valuable nutrient, because it favors intestinal absorption of calcium, magnesium and phosphorus, and the utilization of Vitamin D. Lactose is of major importance for maintaining osmotic equilibrium between the blood stream and the alveolar cells of the mammary gland during milk synthesis, and secretion into the alveolar lumen and the duct system of the udder.

Compared to cow milk, lactose contents in goat milk are at about the same level but sheep milk contains about 1 percent more lactose than cow milk and goat milk. Protein and fat levels in sheep milk are much higher which makes sheep milk lactose less in proportion to their total solids compared to cow and goat milk total solids. Individuals with intolerance to milk sugar can tolerate goat and sheep milk because it is easier to digest.

Carbohydrates other than lactose found in sheep and goat milk are oligosaccharides, glycopeptides, glycoproteins, and nucleotide sugars in small amount; however they are more compared to cow milk. Milk oligosaccharides have considerable antigenic properties and are valuable in growth promotion of the intestinal flora of the newborn. Goat milk has oligosaccharides with a composition similar to that of human milk. These compounds reach the large intestine undigested and act as prebiotics.

Nucleotide sugars in milk are of particular interest, since they are the glycosyl donors for glycosyl transferase in milk and mammary gland, and are the precursors of glycoproteins, glycolipids, and oligosaccharides in the biosynthesis of milk. Goats have a remarkably high nucleotide content of about 154 μmol/100 ml in normal milk, followed by sheep (93 μmol/100 ml), and cow milk (68 μmol/100 ml). Colostrum, however had 271 μmol/100 ml for goats, 499 μmol/100 ml for sheep, and 58 μmol/100 ml for cows, respectively, while human milk contained low levels at 5 μmol/100 ml in normal milk and 6 μmol/100 ml in colostrums (Johke, 1974).

Minerals and vitamins

Functional components of goat milk also include minerals (Table 7). In terms of mineral composition, goat milk surpasses cow milk in the content of calcium, phosphorus and potassium. The mineral content of goat milk is 3 to 4 times that of woman's milk, which is a considerable burden on kidneys in infants. For this reason, it is recommended that goat milk be given to infants (preferably over 6 months of age) after dilution and supplementation of missing components (Park *et. al*., 2007).

Milk is the first food and contains a rich array of vitamins necessary for normal growth of young organisms. The most important are fat-soluble vitamins A (axerophtol), D (calcipherol), E (tocopherol) and K (menaquinones, phylloquinone) and water-soluble vitamins B1 (thiamine), B2 (riboflavin), B6 (pyridoxine), PP (nicotinic acid, niacin), B12 (cobalamine), pantothenic acid, C (ascorbic acid) and H (biotin). After precipitation of milk proteins, water-soluble vitamins mostly pass into whey. Comparative studies of goat and cow milk suggest that both types of milk contain similar amounts of vitamins B6 and pantothenic acid. The concentration of both water-soluble and fat-soluble vitamins are more in sheep's milk compared to goat's and cow's milk and the retinol activity of sheep's milk is twice that of goat's milk may due to higher fat content. (Tamime, 1996)

Goat milk is higher in niacin, vitamins A and C (tab. 6). Orotic acid (vitamin B13) takes part in conversion of folic acid and vitamin B12, reduces cholesterol concentration in the blood, has detoxifying and antiarthritic action (reduces the concentration of uric acid in the blood), prevents over-fatness of tissues, increases body weight gains through muscle mass gain and growth of connective tissue, as well as protecting parenchymatous organs (liver, kidneys) and the heart from degeneration, cirrhosis and steatosis. Orotic acids are found in all organs, mainly the liver, spleen and heart, with considerable amounts found in milk. Vitamin B13 acid content in the milk of sheep is highest and amounts to 350-450 mg/l, 100 mg/l of bovine milk, 63 mg/l of goat milk and 7 mg/l human milk (Milewski, 2006). The information presented on the pro-health properties of goat milk suggest paying more attention to this product. Increased consumption of milk and its products can be one of the most effective, while the cheapest, components in the prevention of lifestyle diseases: hypertension, atherosclerosis, obesity, diabetes and cancer.

The Se availability of human milk (11.1%) was significantly higher compared to that of cow (6.8%), goat (6.2%) and sheep milk (<2%). Further study suggested that the Se availability may be related to the gastric digestibility of protein. The high Se availability of human milk might be attributed to the high gastric digestibility of human milk protein. It was found that removal of the milk fat fraction increases *Se* availability (Lihua *et al.*, 1996).

Regular consumption of goat milk by anemic patients improves their recovery because it enhances the nutritional use of iron and enhances the regeneration of hemoglobin, which means goat milk minimizes calcium and iron interactions. Conversely, it protects DNA stability, even in cases of iron overload caused by prolonged treatments with this mineral to treat anemia.

Goats are much more flexible and limber than cows. The reason for this is that goats are a bioorganic sodium animal, while cows are a calcium animal.

Table.1 Chemical composition of ruminant and human milk*

Components	Cow	Sheep	Goat	Human
Solids	12.3	18.2	13.2	12.4
Fat	3.4	7.1	4.0	3.8
Total Protein:	3.2	5.7	3.6	1.2
Casein	2.5	4.6	2.9	0.4
Whey Proteins	0.65	1.08	0.61	0.7
Lactose	4.6	5.4	4.5	7.0
Minerals	0.7	0.9	0.8	0.2
Energy (kcal/100g)	66	97	70	63

*Kon and Cowie (1961), Posati and Orr (1976), Alichanidis and Polychroniadou (1996)

Table.2 Content and Composition of casein in ruminant milk*

Casein fractions	Goat	Sheep	Cow
Percent of total casein			
αS1	5	16	38
αS2	25	15	10
β	50-64	39-47	33-39
κ	10-20	7-10	11-13
Others	2.5	4.8	6.2
Content in milk (%)			
αS1	0.12	0.69	0.92
αS2	0.53	0.55	0.21
β	1.29	1.72	0.91
κ	0.31	0.36	0.25
Others	0.07	0.27	0.15
Total	2.12	3.59	2.44

* Belloni-Businco *et al*., (1999), Squergin *et. al*., (1997), Tamime *et al*., (2011)

Table.3 Composition and content of whey proteins in total whey proteins and skimmed milk*

Whey protein fractions	Cow	Goat	Sheep
Percent of total whey proteins			
α- lactalbumin	16.2	21.4	10.8
β- lactoglobulin	59.3	54.2	61.1
Lactoferrin	9.5	12.8	8.1
Immunoglobulins	15.0	11.5	20.0
Content in skimmed milk (%)			
α- lactalbumin	0.11	0.13	0.12
β- lactoglobulin	0.38	0.33	0.66
Lactoferrin	0.06	0.08	0.09
Immunoglobulins	0.10	0.07	0.21
Total	0.65	0.61	1.08

* Belloni-Businco *et al*., (1999), Squergin *et al*., (1997)

Table.4 Average lipid composition of milk (100 g) of 4 species *

Fatty Acids	Sheep	Goats	Cows	Human
Saturated FA, g	4.60	2.67	2.08	2.01
C4:0, g	0.20	0.13	0.11	0.01
C6:0, g	0.14	0.09	0.06	0.01
C8:0, g	0.14	0.10	0.04	0.01
C10:0, g	0.40	0.26	0.08	0.05
C12:0, g	0.24	0.12	0.09	0.25
C14:0, g	0.66	0.32	0.34	0.31
MCT total				
(C6-C14), g	0.58	0.89	0.61	0.64
C16:0, g	1.62	0.91	0.88	0.92
C18:0, g	0.90	0.44	0.40	0.29
Monounsat. FA, g	1.72	1.11	0.96	1.66
C16:1, g	0.13	0.08	0.08	0.13
C18:1, g	1.56	0.98	0.84	1.48
C20:1, g	-	-	trace	0.04
C22:1, g	-	-	trace	trace
Polyunsat. FA, g	0.31	0.15	0.12	0.50
C18:2, g	0.18	0.11	0.08	0.37
C18:3, g	0.13	0.04	0.05	0.05
C18:4, g	-	-	-	trace
C20:4, g	-	-	trace	0.03
C20:5, g	-	-	trace	trace
C22:5, g	-	-	trace	trace
C22:6, g	-	-	trace	trace

*Kon and Cowie (1961), Posati and Orr (1976), Renner (1982)

Table.5 Fatty acid profile (%) of milk fat ruminants*

Species	SFA	UFA	MUFA	PUFA	UFA/SFA	MUFA/FUFA
Sheep's	65.60	34.40	27.10	7.30	0.52	3.71
Cow's	72.80	27.20	22.70	5.20	0.37	4.36
Goat's	64.50	35.50	29.93	5.57	0.55	5.34

*Jenness (1980)

Table.6 Cholesterol content of ruminant and human milk*

Species	Cholesterol (mg/100ml)
Goat	12-14
Sheep	26-29
Cow	13-14
Human	14-16

*Park and Haenlein (2006)

Table.7 Mineral and Vitamin contents (amount in 100g) of ruminant and human milk*

Constituents	**Milk**			
	Goat	**Sheep**	**Cow**	**Human**
Minerals (mg)				
Ca	134	193	122	33
P	121	158	119	43
Mg	16	18	12	4
K	181	136	152	55
Na	58	44	41	15
Cl	150	160	100	60
S	28	29	32	14
Fe	0.07	0.08	0.08	0.20
Cu	0.05	0.04	0.06	0.06
Mn	0.032	0.007	0.02	0.07
Zn	0.56	0.57	0.53	0.38
Vitamins				
Vitamin A (IU)	185	146	126	190
Vitamin D (IU)	2.3	0.18µg	2.0	1.4
Thiamine (mg)	0.068	0.08	0.045	0.017
Riboflavin (mg)	0.21	0.376	0.16	0.02
Niacin (mg)	0.27	0.416	0.08	0.17
Panthothenic acid (mg)	0.31	0.408	0.32	0.20
Vitamin B6 (mg)	0.046	0.08	0.042	0.011
Folic acid (µg)	1.0	5.0	5.0	5.5
Biotyn (µg)	1.5	0.93	2.0	0.4
Vitamin B12	0.065	0.712	0.357	0.03
Vitamin C	1.29	4.16	0.94	5.00

*Alichanidis and Polychroniadou (1996)

Table.8 Amino acid composition of goat, sheep, cow and human milk (per 100 g)*

	Sheep	Goats	Cows	Human
Essential amino acids:				
Arginine, g	0.198	0.119	0.119	0.043
Histidine, g	0.167	0.089	0.089	0.023
Isoleucine, g	0.338	0.207	0.199	0.056
Leucine, g	0.587	0.314	0.322	0.095
Lysine, g	0.513	0.290	0.261	0.068
Methionine, g	0.155	0.080	0.083	0.021
Phenylalanine, g	0.284	0.155	0.159	0.046
Threonine, g	0.268	0.163	0.149	0.046
Tryptophan, g	0.084	0.044	0.046	0.017
Valine, g	0.448	0.240	0.220	0.063
Non-essential amino acids				
Alanine, g	0.269	0.118	0.113	0.036
Aspartic acid, g	0.328	0.210	0.250	0.082
Cystine, g	0.035	0.046	0.030	0.019
Glutamic acid, g	1.019	0.626	0.689	0.168
Glycine, g	0.041	0.050	0.070	0.026
Proline, g	-	0.368	0.319	0.082
Serine, g	0.492	0.181	0.179	0.043
Tyrosine, g	0.281	0.179	0.159	0.053

*Posati and Orr (1976)

Bioorganic sodium is known in Naturopathic Medicine as the youth element. Arthritis does not come with old age. It is a lack of this essential mineral that brings on the symptoms of old age. The highest sources of bioorganic sodium are found in goat milk and sweet goat whey.

Goat milk is rich in calcium and phosphorus, which is highly bioavailable and favors their deposition in the organic matrix of bone, leading to an improvement in bone formation parameters. It also has more zinc and selenium, which are essential micronutrients contributing to the antioxidant defense and for the prevention of neurodegenerative diseases (Sreeraman, 2011).

Nutritional and medical aspects

The nutritional advantage of goat milk over sheep milk actually comes not from its protein, mineral or vitamin differences, but from the lipids, or more specifically the fatty acids within the lipids (Babayan, 1981). The fat of goat milk is more digestible than that of cow milk because the fat globules of goat milk are smaller and have a greater area, and lipases in the gut are supposedly able to attack the lipids more rapidly. However, almost 20% of the fatty acids of goat milk fall into the short-chain fatty acids category (C4:O to C12:O) compared with 10-20% for cow milk. Lipases attack the ester linkages of the shorter-chain fatty acids more readily, so these differences may contribute to more rapid digestion of goat milk fat (Jenness, 1980). The proteins in goat milk are digested more readily and their constituent amino acids absorbed more efficiently than those of cow milk (Boulanger *et al*., 1984).

Goat milk is very useful for people suffering from problems such as acidity, eczema, asthma, migraine, colitis, stomach ulcer, digestive disorder, liver and gallbladder diseases and stress-related symptoms such as insomnia, constipation and neurotic indigestion (Babayan, 1981). These patients may in future turn more to goat milk and its products to solve their problems.

Caproic, caprylic, capric and other medium-chain fatty acids have been used for the treatment of malabsorption syndromes, intestinal disorders, coronary diseases, premature infant nutrition, cystic fibrosis and gallstone problems because of their unique metabolic ability to provide energy while at the same time lowering, inhibiting and dissolving cholesterol deposits (Greenberger and Skillman, 1969; Kalser, 1971; Tantibhadhyangkul and Hashim, 1975; Tantibhadhyangkul and Hashim, 1978; Haenlein, 1992). Goat milk is recognized for its superior nutritional quality, and is an important source of milk constituents for individuals suffering from an allergy to cow milk (Gupta and Mathur, 1991).

Biological and Immunological aspects

The biological value and digestibility coefficient of goat milk casein were found to be 89.29 and 92.42, respectively (Kumar *et al*., 1986). Goat milk is easier to digest because of its natural homogenization, which is superior to the mechanical homogenization of cow milk. This is because it takes approximately 20% less time to digest goat milk as the size of its fat globules varies from 0.1 to 10 microns, with the greater proportion being less than 2 microns, while the reverse is true in cow milk (Cornell and Pallansch, 1966; Saini and Gill, 1991). This in turn indicates, and may explain, the significant differences in the ability to digest cow milk shown by infants and other patients (Mack, 1953).

There is extensive immunological cross-reaction of cow and goat milk proteins. The non-allergenic properties of goat milk are due to the fact that most of the milk proteins are unable to pass through the walls of the digestive tract in their original, undigested, allergenic states (Saini and Gill, 1991). The immunological behaviour of the β-Lg of goat and sheep milk suggests that the differences in amino acid composition do not affect the anti-genitally active sites of these molecules (Johke *et al*., 1964, Bell *et al*., 1968).

References

Alferez, M.J.M., Barrionuevo, M., Lopez Aliaga, I., Sanz Sampelayo, M.R., Lisbona, F., Robles, J.C. and Campos, M.S. 2001. “Digestive utilization of goat and cow milk fat in malabsorption syndrome.” J. Dairy Res. 68: 451–461.

Alichanidis, E. and Polychroniadou, A. 1996. Special features of dairy products from ewe and goat milk from the physicochemical and organoleptic point of view. In: Proceedings, Production and Utilization of Ewe and Goat Milk, Crete, Greece, Oct. 19-21, 1995, International Dairy Federation Publ., Brussels, Belgium, p. 21-43.

Assis, P. O. A. de, Guerra, G. C. B., Araújo, D. F. de S., Araújo Júnior, R. F. de, Machado, T. A. D. G., Araújo, A. A. de and Queiroga, R. de C. R. do E. 2016. Intestinal anti-inflammatory activity of goat milk and goat yoghurt in the acetic acid model of rat colitis. International

Dairy Journal, 56: 45–54.
Babayan, V.K. 1981. Medium chain length fatty acid esters and their medical and nutritional application. J. Am. Oil Chem. Sot., 59: 49A-5 IA.
Ballabio, C., Chessa, S., Rignanese, D., Gigliotti, C., Pagnacco, G., Terracciano, L. and Caroli, M. 2011. Goat milk allergenicity as a function of αs-casein genetic polymorphism. Journal of Dairy Science, 94(2): 998–1004.
Barrionuevo, M., Alferez, M.J.M., Lopez Aliaga, I., Sanz Sampelayo, M.R. and Campos, M.S., 2002. "Beneficial effect of goat milk on nutritive utilization of iron and copper in malabsorption syndrome." J. Dairy Sci. 85: 657–664.
Basu S., Smedman A. and Vessby B. 2000. Conjugated linoleic acid induces lipid peroxidation in humans. FEBS Letters, 486: 33-36.
Bath, A. M. and Christopher D Lu. 2019. Current status of global dairy goat production: an overview. Asian-Australas J Anim Sci., 2019 Aug; 32(8): 1219–1232.
Belloni-Businco B., Paganelli R., Lucenti P., Giampietro P. G., Perborn H.and Bussinco L. 1999. Allergenicity of goats milk in children with cow.s milk allergy. J. Allergy Clin. Immunol., 103: 1191-1194.
Bernacka H. 2005 Effect of Breed and Feeding Season on the Nutritive Quality of Goat's Milk. Fol. Biol. (Kraków) Suppl. 53: 99-106.
Boulanger, A., Grosclaude, F. and Mahe, M.F., 1984. Polymorphism of caprine α S-1 casein and α S-2 casein. Genet. Sel. Evol., 16: 157-175.
British Dairy Sheep Association. 2006. Cited from www.sheepdairying.com
Cornell, D.C. and Pallansch, M.J., 1966. Counting and sizing fat globules electronically. J. Dairy Sci., 49: I37 I - 1375.
Cossignani, L., Giua L., Urbani E., Simonetti M.S., and Francesca B. 2014. Fatty acid composition and CLA content in goat milk and cheese samples from Umbrian market. Eur Food Res Technol. 21:1 - 8
FAO. 2010. 2009 Production Yearbook. Food Agr. Organ., UN. Rome, Italy.
Francesco Giansanti, Gloria Panella, Loris Leboffe, and Giovanni Antonini 2016. Lactoferrin from Milk: Nutraceutical and Pharmacological Properties. Pharmaceuticals (Basel). 9(4): 61-76
Greenberger, N.J. and Skillman, T.G. 1969. Medium chain triglycerides. Physiology considerations and clinical implication. N. Engl. J. Med., 280: 1045-1058.
Gupta, N. and Mathur, M.P. 1991. Purification and ribonuclease from goat milk. Indian J. Dairy Sci., 44: 529-531.
Haenlein, G. 2002. Lipids and proteins in milk, particularly goat milk. Technical Report.
Haenlein, G. 2004. Goat milk in human nutrition. *Small Ruminant Res*. 51(2):155–163.
Haenlein, G.F. 1996. Status and prospects of dairy goat industry in the United States. *J. Anim. Sci*. 74:1173–1181.
Haenlein, G.F.W. 1992. "Role of goat meat and milk in human nutrition." In: Proceedings of the Fifth International Conference on Goats, vol. II, part II. Indian Council of Agricultural Research Publishers, New Delhi, India, pp. 575–580.
Ip, C., Banni, S., Angioni, F., Carta, G., McGinley, J., Thompson, H.J., Barbano, D. and Bauman, D. 1999. Conjugated linoleic acid-enriched butter fat alters mammary gland motphogenesis and reduces cancer risk in rats. J. Nutr. 129: 2135–2142.
Jahreis G., Fritsche J. and Steinhard H. 1996 Monthly variations of milk composition with special regard to fatty acids depending on season and farm

management systems: conventional versus ecological. Fett/Lipids, 98: 356-362.

Jenness, R., 1980. "Composition and characteristics of goat milk: A Review 1968–1979." J. Dairy Sci. 63: 1605–1630.

Johke, T. 1974. Nucleotides of mammary secretions. In: Lactation, vol. 4., Larson, B.L., Smith, V.R. (Eds.). Academic Press, New York, pp. 513–522.

Johke, T., Hageman, E.C. and Larson, B.L. 1964. Some immunological relationship of α-lactalbumin and β-lactoglobulin in milk of various species. J. Dairy Sci., 47: 28-31.

Kaiser, M.H., 1971. Medium chain triglycerides. Adv. Int. Med., 17: 301-320.

Kon, S.K. and Cowie, A.T. 1961. Milk: the Mammary Gland and its Secretion. Academic Press, New York, NY, 2nd Vol., 938 pp.

Kondyli E., Katsiari M. C. and Voutsinas L. P. 2007. "Variations of vitamin and mineral contents in raw goat milk of the indigenous Greek breed during lactation." Food Chemistry, 100: 226-230.

Kumar, V., Chandra, P. and Zachdeva, K.K. 1986. Nutritive value of goat milk. Indian Dairyman, 38: 390-391.

Lihua S., Peter Van Dael, Loop L. and Hendrik D. 1996 "Estimation of selenium bioavailability from human, cow's, goat and sheep milk by an *in vitro* method."Int. J. Food Sci & Nutr. Vol. 47(1): 75-81.

Mack P.B., 1953. A preliminary nutrition study of the value of goat milk in the diet of children. American Goat Society, Year Book 1952-1953. Mena, AR, pp. 112-132.

Mohamed Mansour El-Loly and Mohamed Bahy Mahfouz, 2011. Lactoferrin in Relation to Biological Functions and Applications: A Review. *International Journal of Dairy Science*, 6: 79-111.

Park Y. W. and Haenlein G. F. W. 2006. Handbook of milk of non-bovine mammals Blackwell Publishing, USA PP 1-194.

Park Y. W., Juárez M., Ramos M. and Haenlein G. F. W. 2007 "Physico-chemical characteristics of goat and sheep milk." Small Rum. Res., 68: 88-113.

Posati, L.P. and Orr, M.L. 1976. Composition of Foods, Dairy and Egg Products. USDA-ARS, Consumer & Food Economics Inst. Publ., Washington, D.C., Agr. Handbook, No. 8-1, pp. 77-109.

Raynal-Ljutovac K, Lagroffoul C, Paccard P, Guillet I.and Chilliard Y. 2008.Composition of goat and sheep milk products: an update. Small Rumin. Res. 79: 57-72.

Reklewska B., Ryniewicz Z., Góralczyk M., Kuczyñska B., Karaszewska A.and Zdziarski K. 2002. The effect of a diet containing evening primrose (*Oenothera paradoxa*) vs. whole linseed on the content of functional lipid fraction of goat milk. Anim. Sci. Pap. Rep. 20: 229-244.

Renner, E. 1982. Milk and Milk Products in Human Nutrition. Volkswirtschaftlicher Verlag GmbH Publ., Munich, Germany, 467 pp.

Saini, A.L. and Gill, R.S., 1991. Goat milk: An attractive alternate. Indian Dairyman, 42: 562.

Salva, S., Nunez, M., Villena, J., Ramon, A., Font, G., and Alvarez, S. 2011. Development of a fermented goats' milk containing Lactobacillus rhamnosus: In vivo study of health benefits. Journal of the Science of Food and Agriculture, 91(13): 2355–2362.

Salva, S., Villena, J. and Alvarez, S. 2010. Immunomodulatory activity of

Lactobacillus rhamnosus strains isolated from goat milk: Impact on intestinal and respiratory infections. International Journal of Food Microbiology, 141(1–2): 82–89.
Squergin P., Walter M., Schiltz E., Deichmann K., Forster J. and Mueller H. 1997. “Allergenicity of α-casein from cow, sheep and goat.” Allergy. 52: 293.
Sreeraman V R. 2011. Goat milk similar to human milk: A Spanish Study. Cited from https://www.medindia.net/news/goat-milk-similar-to-human-milk-spanish-study-85260-1.htm
Staista 2020 China: sheep milk production volume 2018. https://www.statista.com/statistics/1048250/china-sheep-milk-production-volume/
Tamime, A.Y. and Deeth, H.C., 1980. Amino acid composition in milk and yoghurt of different species. J. Food Prot., 43: 939-943.
Tamime, A.Y., Wszolek,, M., Božanić, R., Özer B. 2011. Popular ovine and Caprine fermented milks. *Small Ruminant Research* 101: 2-16.
Tantibhadhyangkul, P. and Hashim, S.A. 1975. Medium-chain triglycerides feeding in premature infants: Effects on fat and nitrogen absorption. Pediatrics, 55: 359-370.
Tantibhadhyangkul, P. and Hashim, S.A. 1978. Medium-chain triglyceride feeding in premature infants: Effects on calcium and magnesium absorption. Pediatrics, 61: 537-545.
Thiruvenkadan, A.K. and Chidananda, S. 2018. Status of dairy goat farming in India. In : Proceedings of the 4th International Asian-Australasian Dairy Goat Conference; 2018: Oct 17–19; Tra Vinh, Vietnam. p. 95–101
University of Delaware, Newark, DE. https://ag.udel.edu/extension/information/goatmgt/gm-08.htm

How to cite this article:

Pandya, A. J., A. J. Gokhale and Mallik, J. M. 2020. Overview of Functionality of Goat and Sheep Milk. *Int.J.Curr.Microbiol.App.Sci.* 9(10): 2750-2764.
doi: https://doi.org/10.20546/ijcmas.2020.910.332