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Review Article

Compositional and Technological Properties of Goat Milk and Milk Products A Review

Almaz Genene Tafes*

Ethiopian Meat and Dairy Industry Development Institute, Ethiopia

***Corresponding author:** Almaz Genene Tafes, Ethiopian Meat and Dairy Industry Development Institute, Ethiopia

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Abstract

These review work summaries significant information from different scientific literatures with the objectives of assessing compositional and technological properties of goat milk and milk product. Goats (Capra hircus) were a domestic animal that have unique adaptation abilities to harsh environmental conditions. Goats are multipurpose animals especial their milk has a particular functional and technological advantages. Fresh goat milk is white, opaque, a slightly sweet taste and alkaline in nature. It exhibited lower ethanol stability than bovine milk during alcohol test. Average milk protein content is higher than bovine milk but similar casein fraction of α S1, α S2, β and κ-casein form which the αs1-casein level is lower and κ-casein is approximately equal but β-casein level is higher than bovine casein. Goat milk fat has smaller fat globules, lacks 'agglutinin', contain higher short- and medium-chain fatty acids. The lactose is slightly less than bovine milk. The goat milk has higher iron bioavailability and contain higher calcium, phosphorus, potassium magnesium, chlorine, vitamins B, and vitamin A but lower sodium, sulfur and vitamin E. Goat milk is considered as "functional and nutraceutical drink" since it rich in bioactive components, superior digestibility medicinal property for many disease and lower allergenic properties. Various dairy goat products were produced in many countries including fluid, fermented especially cheeses and yogurt, frozen, condensed and powder milk from which cheese is highly marketable goat milk product.

Keywords: Goat, Milk, Composition, Milk Products

Introduction

Goats (Capra hircus) believed to be the second domesticated animal [1]. Goat have unique abilities of adapting harsh tropical environments than other ruminants and existing in all continents [2-4]. Goats are prolific breeders and achieve sexual maturity at an early age 10-12 months [5]. Major world dairy goat's species are Anglo-Nubian, British alpine, Toggenburg and Saanen [6]. The global dairy goat population was estimated to be 218 million in 2017 while goat milk volume estimated to be 18.7 million tons in the same year [7]. That covers around 2 % a share of the global milk production [8]. Goat milk production gaining great consideration due to the need of functional foods, nutritional interest of goat milk and increase demand for goat milk product as result of increasing human population [9],Health and therapeutic property, looking at alternatives of bovine milk [10] in addition decreasing agriculture, fellow and grazing play role for growth [3]. Goat milk has multiple functions as nutrition and health, gradually becoming the preferred product by consumers [11-13]. Goat milk serves human being as home consumption, specialty sensualist foods and medical-therapeutic uses [14] due to this goat milk and milk product especially goat cheeses have a worldwide growing demand [3,15]. Goats' milk have a particular technological advantages such as its smaller fat globules size, lower amounts of αs1-casein in comparison to bovine 's milk [9]. Therefore, the current review work focuses on assessing important information on compositional and technological properties of goat milk and milk product.

Physical Chemical Property of Goat Milk

Physical properties

Fresh goat milk is white, opaque and slightly sweet taste [15]. Goat milk has comparable density but higher specific gravity, viscosity and titratable acidity, lower refractive index and freezing point than bovine milk while its viscosity lower than buffalo milk [5,16,17]. Goat milk is slightly alkaline in nature while bovine milk slightly acid since the pH is higher than bovine milk [9]. Goat milk exhibited lower ethanol stability than bovine milk during alcohol test due to its higher ionic calcium content in goat milk [16].

Chemical properties

Milk protein: Proteins are organic compounds made of amino acids arranged in a linear chain and folded in to globular [18]. Dairy products are a reliable source of high-quality proteins which are well balanced in amino acids [10]. Even if the compositions of milk determined by various factors like; breed, lactation period, environment, management and health etc. the variation in growth composition between bovine and goat milk is in significant [19,20]. The average protein content of goat milk higher than bovine milk but both have 3 to 4 time's greater protein and ash content than human milk [15] Milk protein mainly categorized into casein and whey protein.

Casein: Casein is a globular protein present in milk as a colloidal suspension of micelles. It is characterized by a hydrophobic core and a charged polar hydrophilic part [21]. Casein has a major impact on nutritional value and technological suitability [22]. The caseins is main protein that cover 80% of total protein and are classified as αs1, αs2, β and κ-caseins similarly goat casein subdivided into a fraction of aS1, aS2, β and κ-caseins form which the αs1-casein level is lower while amounts of β-casein is higher and amounts of κ-casein is approximately equal as compared to bovine milk [20,23,24]. For instance, the amount of goat milk casein fractions aS1, aS2, β- and κ-casein were 10, 3, 11and 4 g/l respectively while amount in bovine milk for each is11-15,3-4,9-11and 2-4 respectively g/l [21]. Goat and bovine milk differ essentially in their casein micelles structure, composition and size [22] as indicated it was generally small in goat milk due to high calcium and phosphorus concentrations. Casein composition of goat milk is influenced by genetic polymorphism.

Indicative report from Ethiopian goat's milk in comparison to crosses bread with local indicts that higher content of αs1 casein, smaller casein micelles and stronger gels was observed in local breeds that could be indicates the suitability of milk of local bread for drinking and production of high quality dairy products [25]. Casein found in milk from Alpine and Saanen goats can be a source of bioactive peptides and have no αs1-casein in their casein composition but no difference in casein composition [19]. Goat κ-casein differs from its bovine complement in having a chain of 171 instead of 169 amino acid residue. However; it likes bovine κ-casein in having the same Phenylalanine at 105 and Methionine at 106 amino acid position enzyme cleavage site. Lower αs1-casein content results softer gel products, higher water holding capacity and lower viscosity [9].

Whey protein: Whey proteins remain soluble at milk pH 4.6 and 20°C temperature after the removal of caseins from milk. Whey is highly bioavailable and has highest biological value with their suitable amino acids than of any protein source and casein. It comprises mainly β-lactoglobulin (β-LG), α-lactalbumin (α-LA), bovine serum albumin (BSA), immunoglobulins and proteose peptone, as well as several minor proteins including lactoferrin, glycoproteins, lactoperoxidase and transferrin [18,26-28]. The amount β-lactoglobulin (β-LG), α-lactalbumin (α-LA), bovine serum albumin (BSA) and lactoferrin in goat milk was 3.1,1.2, 0.5 and 0.02-0.2g/l respectively whereas it was 3-4,0.6-1.5,3-4,0.4and 0.1 g/l in bovine milk whey proteins [21]. The β-lactoglobulin, most know allergenic whey protein and can be prevented by total exclusion of bovine milk consumption [29] or substitution by other mammalian milk source like camel milk that was the most suitable substitute for bovine milk when considering preparation of infant formulas and lower allergenic than bovine 's, donkey's and goat's milk since camel milk has similarity with human milk in absence of β-lactoglobulin. Goat also reported as alternative of bovine milk as it have lower allergenic properties [13,28,30]. Main component of ewe cid whey proteins was β-lactoglobulin while the main component of goat acid whey proteins was α-lactalbumin [26] gastric digestion patterns of caseins and whey indicated that caseins and their peptides precipitate and form a homogeneous firm clot during gastric digestion in the presence of pepsin but whey proteins are resistant to hydrolysis in the gastric environment and a large portion is found soluble in the gastric digester [31].

Fat: Milk fat exists as small globules dispersed in milk serum and size various according to mammalian spices from which buffalo milk has a biggest average diameter (8.7μm), the smallest in camel milk (2.99 μm) ,for bovine , sheep and goat milk is 3.95, 3.78 and 3.19 μm respectively according to [32]. Smaller fat globules make a smoother texture in goat's milk products with a better dispersion and more homogeneous mixture of fat in goat milk, which would provide for lipases a greater surface area of fat for fast digestive action [33]. Goat milk fat globules resemble to that of bovine lipid composition and properties of the globule membrane but it lacks 'agglutinin' that causes fat globules form creaming property or cluster when cooled [6,10]. The lack of agglutinin in camel milk and higher long chain fatty acid [27]. The main characteristic of goat milk fat is its higher content of short- and medium-chain fatty acids [22]. The higher levels of short-chain free fatty acids in goat milk seem to be associated with the development of goaty flavor in its products that were considered as the reasons for such low consumption level of goat milk however, goat milk is less allergenic, naturally homogenized, easier to digest due to a smaller fat globules as well as higher levels of medium chain fatty acids [4,34] and type of amino acid present in its protein on the other hand relatively small size fat globules make ghee preparation of from goat milk unsuitable as it cause problems during separation and associated odor and flavor [24]. Fatty acid composition of goat's milk is also different, being richer in volatile fatty acids (caproic, caprylic, and capric) that are responsible for the specific taste and odor that resulted in dairy products [35].

Lactose: Lactose is the main carbohydrate and synthesized from glucose and galactose in the mammary gland [36]. It favors intestinal absorption of calcium, magnesium and phosphorus and the utilization of vitamin D in goat milk found up to 4.4% as

indicated on different reports it contains slightly less than that of bovine milk by about 0.2–0.5% [10,24].

Minerals and vitamins: Goat milk is characterized by the lowest concentration of iron, zinc, and copper. The bioavailability of goat milk iron is higher than bovine milk due to higher nucleotide content contributing to better absorption in the gut of consumer [10,37]. Goat milk contains higher calcium, phosphorus, potassium, magnesium and chlorine, but lower sodium and sulfur contents than bovine and human milk [5,10,37]. Goat's milk contains less than ten percent of the amount of folic acid [6,38], lower levels of vitamin E, excessive vitamins B, and a higher vitamin A than bovine milk and whiter than bovine/bovine / milk because goats convert all β-carotene in to vitamin A [14,37] but similar amount of vitamin A as human milk and greater amounts of vitamin C than in bovine milk which is a well-known water-soluble antioxidant vitamin [24].

Health Benefit: Functional food is a food component that affects one or a partial function in the body based on that milk is a functional food especially fermented milk products as its value is not only nutrition [39]. Since milk and colostrum are rich in bioactive components which are important to regulate weight, hypertension and influences digestion and health properties. Goat milk is demanded as "functional and nutraceutical drink" as it is rich in bioactive components [24]. The superior digestibility due to proper composition of fatty acids and its content particularly Medium Chain Triglycerides, bioactive compounds seem that give a medicinal properties of goat milk [6,14,24,36,38]. Lactose intolerance is cause because of the deficiency of Lactase which digests milk sugar lactose. Goat milk proves less allergic property while children drinking bovine milk shows protein allergies this might be due to the lower levels of αs1-casein in goat milk [13,36,38], bioavailability nutrient (uptake of Iron and Copper in digestive tract, treatment of cardiovascular, gastrointestinal diseases and anti-thrombotic [36]. Goat milk rich in oligosaccharides with protective function of intestinal flora against pathogens and brain and nervous system development [40] gastrointestinal disturbances, vomiting, diarrhea, constipation and respiratory problems could be eliminated by serving goat milk to the infants [6].

Microbial: Milk have both beneficial microorganisms that have importance for development of flavor, taste, texture and technological or health-related perception and pathogenic microorganisms that create risks associated with the consumption of raw milk and raw milk-derived products [41]. Pathogens introduced in milk at various stages from primary production up to processing either from interior of the udder, exterior surfaces of the goat, environment, milk-handling equipment and personnel while milking procedure, following packaging, storage and delivery of raw milk also occur further contamination [42]. For instance presence of yeasts and moulds in goat milk indicts that improper sanitary conditions of milking area as well as storage equipment while the presence of Coliforms in goat milk identified to be fecal contaminated of milk whereas presence Staphylococcus aureus in goat milk from infected mammary glands during hand milking [43]. Goat milk is composed primarily of Lactobacillus, Lactococcus, Leuconostoc, Enterococcus and Streptococcus species, bacteria with known probiotic and bacteriocinogenic properties whereas *Lactobacillus rhamnosus, L. plantarum*, *L. pentosus*, *L. plantarum*, *L. helveticus* and *E.faecium* from goat cheese from *Lactococcus rhamnosus*, *L. plantarum*, *L.helveticus* and *E. faecium*, known as lactic bacteria frequently occur in goat milk. However, environmental contaminants bacterial including Aquabacterium fontiphilum, *A. fontiphilum*, *Methylibium petroleiphilum*, *Staphylococcus xylosus* and Piscinibacter aquaticus were also isolated from goat milk [11,44]. Probiotic cultures functional in goat milk yogurt as this indicated that goats' milk yogurt could be an excellent carrier for probiotic cultures [45]. Lactic acid bacteria (Lactobacillus and Lactococcus) to be utilized as potential probiotics from goat milk [44]. The most active producers of antimicrobial-active peptides in goat milk were strains of L. delbrueckii subsp. bulgaricus and *S.thermophilus*, which are of practical importance with a significant proteolytic potential in goat milk and in production of dairy products from goat's milk [46].

Heat stability: Heat stability of goat milk influenced by environmental and genetic factors especially slight effect of the αs1-casein genotypes due to that highly variable in heat stability [47]. Similarly, temperature also affecting heat stability since a higher the heating temperature lead to poor heat stability. Higher temperatures 110, 120, 130, and 140 °C decreased the heat stability of both goat milk and bovine milk [16]. Report result from the work done on comparisons of heat stability of milks from several species indicate that goat milk at its natural pH has a lower heat stability than that of bovine however, addition sodium citrate improve heat stability of goat better than bovine milk [16,47]. On the other hand poor thermal stability related physicochemical property of milk where as low pH linked to microbiological characteristics, sanitary condition of raw milk before heat treatments that indicate the need of hygienic handling and shorter time storage of raw milk at 4 °C avoid to pH reduction before UHT treatment [48]. Calcium content had a negative impact on the heat stability of milk goat and bovine. Heat coagulation time (HCT) is 53, 41 and 11min for bovine, buffalo and goat respectively at a temperature of 140 °C that indicates that goat milk relatively has lowest HCT [17]. Highest thermally (at 95 °C /30 min) treated goats' milk had significant impact on the physiochemical properties of goat milk yogurt with higher dynamic viscosity values, lowest whey separation and strong curd [45].

Goat milk products: Raw milk is highly perishable that need handling, processing and strict hygiene. The highest share of world produced milk undergoes variety of technological procedures during processing [32]. Various dairy goat products including fluid, fermented, frozen, condensed and dehydrated milk products are produced in many countries especially cheeses and yogurt [20].

Known products from the goat milk are Roquefort cheese and Leben [24] milk products have high variation in nutritional, chemical and rheological compositions between and within goat products due to the multiplicity of manufacturing procedures, localities, animals, and management factors [49]. The following product discussed as follow;

a. Yoghurt

Yoghurt is a fermented milk product obtained by lactic acid fermentation of milk with the aid of two strains of bacterial cultures–Lactobacillus bulgaricus and Streptococcus thermophiles which confer various beneficial health effect of consumer [50,51]. Yoghurt is typically classified into Set, Stirred, Drinking, Frozen, Concentrated and Flavored Yoghurt [50]. Fermented dairy products are made from milk of almost all domesticated milked animals [52]. Goat milk yoghurt can be made in a similar manner to that of bovine, but goat yogurt result softer and less viscous, often lacks the typical flavor of bovine yoghurt. The addition of bovine skim milk powder to goat milk improves sensory attributes in terms of the characteristics of plain nonfat yoghurt, visual and oral consistency, oral viscosity, sweet taste and lowest score for bitter taste considered the best product [20,53]. The typical sensorial characteristics of goat milk is caprine flavor derived from short and medium chain fatty acids [54] incorporation of beetroot extract at 4% could mask the goaty-flavor and goaty-odor of the yogurt made from goat milk [55]. Frozen yogurt and Ice cream manufactured from Goat milk usually flavored with Vanilla, chocolate, and premium white chocolate [10]. On the other hand, folic acid content could be solved by using folate producing bacteria during fermentation such as *streptococcus thermophilus* and *Lactobacillus delbrueckii subsp*. bulgaricus in goat milk that results in yoghurt with significant quantity of folate and good sensory property [20].

Yoghurt from goat's milk supplemented with Aronia juice and blueberry juice coagulated at a lower acidity and faster than natural yogurt lactic acid bacterial counts in the yoghurt with Aronia and blueberry juice was higher addition of Aronia or blueberry juice to goat's yoghurt increased the amounts of unsaturated fatty acids [35]. Textural property of yoghurt such as firmness and water retention ability determining factors of consumer attribute on product acceptability [45]. Supplementations of polysaccharides appeared to stabilize textural integrity and pH of the commercial goat milk yoghurt [50]. according to the report of [56] result during sensory evaluation show that the taste, appearance, color and flavor were improved by combination of goat and bovine milk than that in the yoghurt made from only goat milk. Strained yoghurt (Labneh) is a cultured milk product which is popular in the Middle East regarding the structural Labneh, Labneh made of goat's contained large void spaces and was softest whereas bovine 's was firmest either by the traditional procedure or by ultrafiltration [57].

Khoa mawa- Mawa made from goat milk is sticky, no release of fat occurs during preparation, yellowish colored with moist surface, hard body and smooth texture can be prepared A premium quality ice-cream can be prepared using goat milk. In America and South Africa Infant Foods prepared from goat milk in evaporated or spray dried form [5].

b. Cheese

Goat cheese was originated from Mesopotamia first with soft cheese followed by hard and rippend cheese which were from Mediterranean regions. Different variety of goat cheese over the world estimated around 400 based on location, composition and manufacturing technique and mostly which are made from goat milk or combinations of goat with bovine, ewe, or buffalo milk [15]. Cheeses hold the greatest economic value among all manufactured goat milk products and based on that leading world cheese exporting country is Germany while leading importing is Italy [58]. Goat milk cheese is easier for human digestive system and lower calories, cholesterol and fat than its bovine cheese but is rich calcium, protein, vitamin A, vitamin K, phosphorus, niacin and thiamin [5].

Goat milk cheese yield influenced by its lesser amount of αs1-casein, milk composition, milk quality, somatic cell count of milk, milk pasteurization, coagulant type, curd firmness at cutting, and manufacturing parameters. The sensory quality of goat cheese affected by short chain fatty (capric, caprylic and caproic acids) that result cheeses in unique tangy flavor similarly sensory quality of goat cheese could be affect by milk somatic cell count, lactation stage, feed, storage ,lipolysis and proteolysis [33,59]. Processing of cheese especially Ezine cheese has a special priority while production of drinking milk should also be increased [60]. Goat cheese has great rate of protein degradation than bovine due to Proteolysis and lipolysis a two main biochemical process during cheese ripping that results chemical, physical and microbial change [61]. Sensory properties of goat cheeses is an important factor on consumer acceptability and marketability [9]. RCT of goat milk is significantly lower than buffalo milk [17]. Goat cheese fortified by flavors, caramel, cocoa and cocoa with walnuts on sweet spreadable goat cheese as economical with high nutritional value, healthy benefits and high scores in organoleptic properties [62]. Good quality paneer free from goat odor could be made from goat milk [5]. Goat's cheeses that analyzed for microbiologically safety have appropriate physical and chemical characteristics [34].

c. Other different goat milk product

Other goat milk products like whey goat milk flavored beverage, tablets (chewable), whey protein concentrate, and athletic supplements were made from goat milk [9]. Cosmetic products such as goat milk soap and hand lotion were produced and marketed in large quantities in many countries including the United States

and evaporated milk, UHT, pasteurized beverages, ice-cream, milk powder and traditional goat milk product manufactured from goat milk [15,24].

Conclusion

In this review work it was found that Goats (*Capra hircus*) were the second domesticated animal that have unique abilities in adapting harsh environments and play great role in particularly for poor and developing countries. Goat milk have unique compositional future as slightly alkaline, lower ethanol stability, higher content of short- and medium-chain fatty acids, Goat milk is a functional and nutraceutical property as it both nutritional and additional health benefit to consumer this lead to increasing demand for goat milk and derived dairy products. This encourages production/farming/ of goat milk and processing of diversified goat milk products that ensure the advantage for goat farmers r pastoralist. Therefore, in goat production potential areas expansion of commercial goat farms, hygienic milk production and establishment of goat milk processing plant need to be considered for quality and diversified product development to fit growing demanded.

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