

As a Potentially Functional Food: Goats' Milk and Products

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Abstract It is important for food materials to be delicious as well as nutritious and natural but, healthy nutrition refers to efficient and balanced nutrition, that is, efficient intake of nutrient elements (lipids, carbohydrates, proteins, vitamins, minerals) for body cells to work smoothly. In the recent years the factors such as the sociological, economic and nutritional value are been significantly impact on the food industry, as a result of these new foods is produced which has the required properties with health-related and is marketed. The products using goats' milk are included this new foods. Goats' milk point of view the nutritional is a valuable dairy product. Goats' milk production is a dynamic and growing industry that is fundamental to the wellbeing of hundreds of millions of people worldwide and is an important part of the economy in many countries. Thus, the lack of at industrial scale increasing the use of goats' milk will be encouraged to more consumption by the community. The aim of the present review is focus on quality and the composition of goats' milk, discuss specialty products made from goats' milk around the world, the importance of goats' milk and usage of goats' milk in food industry were examined.

Keywords: goats' milk, healthy nutrition, food industry

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1. Introduction

A nutraceutical food may provide expanded utility beyond its nutritional benefit. These benefits can be both physical and mental and are commonly attributed to the active components of the food. Today's functional foods are typically marketed to large groups of the total population. Scientific evidence confirming the relationship between food and health has promoted the rapid development of a new food market in recent years: the functional food market [1,2]. In addition to interest of industries and consumers for functional foods has been exponentially increasing. According to the Consensus Document issued by the European Concerted Action on Science of Functional Foods, a food may be referred to as "functional", if it has been unequivocally proven that it positively influences one or more biological functions in the human body, improving the state of health and wellness, and reducing the risk to develop a disease [3,4]. Goats' milk nutritional properties and lower allergenicity in comparison to cow milk, especially in nonsensitized children [5-11], has led to an increased interest in goat milk as a functional food, and it now forms a part of the current trend to healthy eating in developed countries [11,12,13]. Thus, the use of milk with particular nutritional properties (e.g., goats', mares' and donkeys' milk), alone or in combination with bacterial strains having probiotic properties and producing physiologically active metabolites, represents one of the technology

options for manufacturing new dairy functional beverages [4,14].

The importance of goats as providers around the world of essential food in meat and dairy products has been discussed and documented in many recent proceedings of national and international conferences [6,15-21]. The use of goat milk as an excellent food source is undeniable. It has beneficial effects for health maintenance, physiological functions, in the nutrition of children and elderly people, and according to some authors, can be consumed without negative effects by people suffering cow milk allergy. Goat (*Capra hircus*) milk production is of significant importance to the economy and survival of large populations of many countries in the world: in developing countries (i.e. Asia, Africa, the Middle East and Mediterranean countries and South America) as well as in developed countries (i.e. Europe, North America and Oceania) [22,23].

Goat milk shows great variability in biochemical composition, technological properties and bacteriological quality [24-29] depending on genetic factors, environmental conditions, and goat farming practices [29,30,31]. Following factors can be counted as factors affecting milk production in goats. These factors are; pure breeding, crossing, age, birth season, birth type, duration of lactation and dry period, milking type, frequency and duration of milking, mating season, first pregnancy age, survival rate of kids, nutrition and diseases [32]. For example lactation period and milk yield of Saanen goat raised at Aegean Sea region ranged 213 d and 286.8 kg; 247d and 691.4 kg in first and second lactation periods, respectively. Averages

of these values after 8 years of control studies were 213.4 d and 423.09 kg, respectively [32,33].

Goats' milk cheese is generally made in small artisanal units by traditional technology [34,35,36] and has a special taste and flavour very different from that of cows' milk cheese [36,37]. Raw goats' milk cheese represents a significant proportion of ripened cheeses in most Mediterranean countries [36,38]. But cheeses made under these conditions may not have the minimum hygiene and sanitary standards necessary to obtain consistent product quality [36,39]. Most reports of processing of goats' milk do not include pasteurisation [35,36,39,40]. The consumption of cheese made from unpasteurised goats' milk has been identified as the cause of epidemics of brucellosis [36,40,41,42], listeriosis [36,43] and food poisoning due to enterotoxin production by *Staphylococci* [36,43,44,45].

Many traditional dairy products (mainly cheeses) that are accepted by the consumers worldwide are made from sheep or goat milk or from their mixtures. As the composition of cheese milk affects the characteristics and therefore the acceptability of the final product, there is an increased demand for genuine and accurately labeled dairy products, which necessitates protection against adulteration of milk kinds. The substitution of sheep milk

by goat milk in the dairy products is a frequent problem, because sheep milk has a higher price. In addition to that, there are mixed flocks of goats and sheep that results in accidental or fraudulent substitution of sheep milk by caprine and vice-versa [46].

Milk production of goats is likely to be much greater than in these official statistics, because of the large amounts of unreported home consumption, especially in developing countries [6]. Goat milk and its processed products are greatly useful as functional foods, maintaining nourishment and health for young and elderly, especially those who have cow milk allergy.

1.1. Goats' Types and Population of World

The goat population has been described as comprising three main types; namely, fiber goats (e.g. Angora, Cashmere), dairy goats (e.g. Saanen, Toggenburg Nubian), and meat goats (e.g. Boer, Spanish). Annual mean milk production per goat is 84.3 kg in worldwide. When countries are ranked based on annual milk production per goat, Germany comes first with a 972.2 kg, Belarus is second with 819.1 kg and Czech Republic comes third with 750.0 kg. However, Turkey is ranked 43th with 104.9 kg [32,47,48].

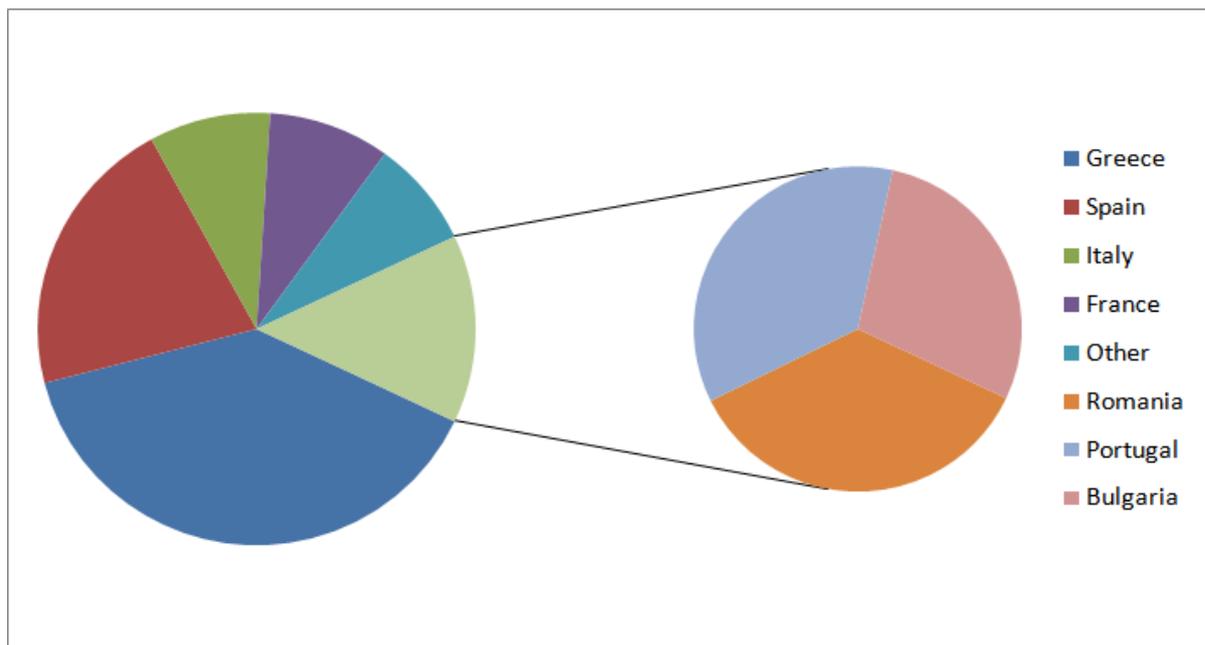


Figure 1. The share of EU countries in the presence of goat (the average of 1975- 2007 years) (Source: FAOSTAT)

The world's goat population was around 867 million in 2009, with over 60% of that found in Asia and more than 95% in developing countries [49,50] and according to Food and Agriculture Organization of the United Nations [51], the worldwide dairy goat population reached 191 million in 2010. The populations of dairy goats in the USA and the European Union in 2010 were 356,000 and 7,732,631, respectively [52]. In developed countries, after 100 years of lower production, the position of goat farming has turned positive again. During the last 20 years, the number of goats around the world has increased by about 60%, not only in the countries with low incomes (75%) but also in those with high (20%) and intermediate (25%) incomes [53,54,55]. China has the largest goatherd with 195.6 million, followed by India with 120.0 million,

and Pakistan 56.7 million. China, India, Pakistan, Indonesia and Bangladesh together contribute 78% of the total small ruminant population in Asia [50,56]. In Pakistan, the Damani and Kamori breeds are popular, while in other countries popular breeds are Barbari, Beetal, Jamnapari, Malabar, Damascus, Barky and Black Bengal [50]. Since 1990, there has been a significant increase (47%) in goat numbers all over the world [32]. But, the goat population in Mediterranean countries has decreased significantly over the last three decades. FAO statistics point to an average decline of 0.5% each year between 1976 and 1992 [57,58]. The presence of goat of EU are given in Figure 1 and number of sheep and goats the members of in some Mediterranean countries of EU are given in Table 1.

Table 1. Number of sheep and goats the members of in some Mediterranean countries of EU

Countries	The presence of Goat (1)	(1/3) (%)	(1/4) (%)	The presence of Sheep (2)	(2/3) (%)	(2/4) (%)
France	1235116	7.1	8.8	8982004	12.2	8.2
Greece	5557894	32.1	39.7	8896379	12.0	8.1
Italy	965396	5.6	6.9	8075328	10.9	7.3
Portugal	2941151	17.0	21.0	22688755	30.7	20.6
Turkey	6635815	38.3	-	25302204	34.2	-
Total (3)	173335371	100.0	-	73944670	100.0	-
EU (4)	14009482	-	100.0	109972922	-	100.0

Kaynak: FAOSTAT

Turkey has the largest goat population in Europe (5.600.000 t in 2009) and is fourth in total goat milk production (192.000 t in the year 2009) in the European and Mediterranean region, after France, Spain, and Greece [54,55]. Goat growing is concentrated primarily in mountainous zones and arid areas. It is adapted to the climatic conditions of the country and ensures production of meat, milk and leather. Goats' milk plays a significant role in the diet of the inhabitants of these areas [59]. Goat farming is highly common in Turkey due to geo-graphical and economical conditions of Turkey, agricultural background and traditions of Turkish people. Turkish goat population comprises of hair, Angora and dairy goats. Based on 2009 statistics, Turkish goat population is ranked 27th in World with 5.128.285 and has great potential as number of goats. Majority of Turkish goat population consists of hair goat, followed by Angora, dairy and their cross-breeds. Contribution of goat into meat and milk production as percentage in animal production sector is considerable [32,47].

With its 7.022.000 goats, Turkey ranks first in Europe. In contrast to the size of the goat population, only 219.795

t of goats' milk is produced annually, which represents 2.3% of the total milk production of the country [60,61]. The reason for the low goats' milk production is that the majority of the goat population (93.4%) is composed of indigenous Hair goats with low milk yields (70-150 kg/lactation) [61,62,63] and short lactation periods (154 days) [61,64]. Some attempts have been made to improve the production of goats' milk by crossing the indigenous breed with exotic breeds in this region [62,63]. Promising results were reported on German FawnxHair goat cross breeds in terms of milk yield [61,62], but the gross composition of the goats' milk during the lactation was not given. Goat and sheep farming are of vital importance for the national economy in many countries in the Mediterranean and Middle East region, and particularly well organized in France, Italy, Spain and Greece [65,66]. Among the European countries, Greece is the first in goat population (6.000.000 animals) and produces about 450.000 t of goat milk per year [66,67]. France has nearly 1 million goats and occupies the first place in the European community in terms of milk production [68].

Table 2. Average composition of basic nutrients in goat, sheep, cow and human milk

Composition	Goat	Sheepa	Cow	Human
Fat (%)	3.8	7.9	3.6	4.0
Solids-non-fat (%)	8.9	12.0	9.0	8.9
Lactose (%)	4.1	4.9	4.7	6.9
Protein (%)	3.4	6.2	3.2	1.2
Casein (%)	2.4	4.2	2.6	0.4
Albumin, globulin (%)	0.6	1.0	0.6	0.7
Non-protein N (%)	0.4	0.8	0.2	0.5
Ash (%)	0.8	0.9	0.7	0.3
Calories/100 ml	70	105	69	68

1.2. Composition of Goats' Milk

Compositions of goat, sheep, cow and human milks are different and are given in Table 2 [24,25,65,69,70,71], but vary with diet, breed, individuals, parity, season, feeding, management, environmental conditions, locality, stage of lactation, and health status of the udder [25,65,69-78]. Goat milk differs from cow or human milk in having better digestibility, alkalinity, buffering capacity, and certain therapeutic values in medicine and human nutrition [65,71,79,80]. The average composition of goats' milk does not differ remarkably from that of cows' milk. Goats' milk has some particular properties that confer technological advantages in comparison to cow's milk, such as a smaller size of fat globules, which provides a smoother texture in derived products, lower amounts of as1-casein, resulting in softer gel products, a higher water

holding capacity and a lower viscosity [6,81-85]. However, the flavour of goat's milk is more intense in comparison to cow's milk, which can restrict the acceptance of its derivatives by consumers [85]. However, essential differences are present with regards to the structure, composition and size of the casein micelles, the proportion of individual protein fractions and higher content of nonprotein nitrogen and mineral compounds in goats' milk [82,86]. The basic nutrient composition of goat milk resembles cow milk, where both milks contain substantially higher protein and ash, but lower lactose content than human milk [25,71,77,87]. Goat milk reportedly has higher fat and ash contents in the tropics than cow counterparts [25,77,87], although Holstein cow milk fat is similar to that in milk of Swiss goats. On the other hand, literature on basic nutrient compositions of different types of manufactured goat milk products has been extremely limited. Mineral contents of goat milk

from French-Alpine and Anglo-Nubian breeds showed higher Ca, P, K, Mg, and Cl, and lower Na and S levels than bovine milk [79,87]. Mineral contents of commercial US goat milk yogurt have been shown to have significant differences in the levels of Ca, Mg, P, Fe, Zn, and Al between different yogurt varieties [80,87]. Mineral concentrations of 30 varieties of commercial goat milk cheeses produced in the US revealed that there were wide variations in concentrations of P, K, Ca, Na, Cl, Fe, Al, and Zn among and within varieties of the cheeses [87,88]. Sheep milk has higher specific gravity, viscosity, refractive index, titratable acidity, and lower freezing point than average cow milk [65,89]. Lipids in sheep and goat milk have higher physical characteristics than in cow milk, but there are variations between different reports [65,78,90].

Variation in the chemical composition of goat milk is, however, highly seasonal. The major constituents of goat milk are high in early lactation, decline rapidly, then remain low for a variable length of time, and increase

again towards the end of lactation [91,92]. However, lactose content is independent of stage of lactation [76,92]. The gross composition of goat milk is on the average higher than that in bovine milk, except for lactose that is lower [25,71,92,93]. There are also significant differences between the physico chemical characteristics of casein micelles of caprine and bovine milk [92,94]. Chemical composition of goat milk is influenced by a number of factors, including breed, individual differences, diet, season, stage of lactation, and environment [25,88,93,94]. Milk composition varies according to several factors, such as animal, feed and environment. An example is given in Table 3 for goat milk [23,95,96,97]. It is well known that the composition of goats' milk changes throughout lactation [24,61,76,98]. Any changes in milk composition will be reflected in the nutritional, technological and economic values of goats' milk as well as of other dairy products. Therefore, the extent of these changes should be determined in order to ensure standard production of dairy products [61].

Table 3. Composition of goat milk according to breed and country

Country	Breed	Total solids (%)	Fat (%)	Proteins (%)	Caseins (%)	Lactose (%)	Ash (%)
United Kingdom	British Saanen	11.6	3.48	2.61	2.30	4.30	0.80
United Kingdom	Nubian	-	4.94	3.60	-	4.51	-
Francea	Alpine/Saanen		3.6	3.2			
Italy	Sardinian		5.1	3.9			0.71
Greece	Local	14.8	5.63	3.77	3.05	4.76	0.73
Cyprusb	Damascus	13.2	4.33	3.75	2.97	-	0.83
Spain	Murciano-Granadina			4.09	3.21		

aPirisi et al., (2007)

bPsathas (2005)

The variability in milk composition, among individual animals of the same breed, is attributed to an extensive and complex genetic polymorphism of the goat milk caseins [6,23,99]. A particular characteristic of goat milk is the minor solvation and heat stability of caseinate micelles, and the higher content in β -CN with respect to α_{s1} -CN than in bovine milk [6,23,100]. It is well known that plasmin (PL) is the principle indigenous proteinase in milk and that the increase in plasmin activity can lead to casein degradation in milk and reduction in cheese yield. Caprine milk contains the entire PL system: PL, plasminogen (PG), PL inhibitors, PG activators and

inhibitors of PG activators [6,23,101], and recently the specificity of PL on goat β -caseins has been investigated [6,23,102].

Some major reviews exist concerning the biochemical composition of goat and sheep milk and their variation [25,97,103,104,105] but data concerning specific molecules with nutritional properties, e.g. fatty acids and their variability, cholesterol, oligosaccharides, are scant. Moreover, milk yields have increased and milk composition has changed in Western Europe [96,97] owing to an intensification of breeding systems including feeding and genetic selection.

Table 4. Average amino acid composition (g/100 g milk) in proteins of goat and cow milk

	Goat milk	Cow milk	Difference (%) for goat milk
Essential amino acids			
Tryptophan	0.044	0.046	
Threonine	0.163	0.149	+9
Isoleucine	0.207	0.199	+4
Leucine	0.314	0.322	
Lysine	0.290	0.261	+11
Methionine	0.080	0.083	
Cystine	0.046	0.030	+53
Phenylalanine	0.155	0.159	
Tyrosine	0.179	0.159	+13
Valine	0.240	0.220	+9
Non-essential amino acids			
Arginine	0.119	0.119	
Histidine	0.089	0.089	
Alanine	0.118	0.113	
Aspartic acid	0.210	0.250	
Glutamic acid	0.626	0.689	
Glycine	0.050	0.070	
Proline	0.368	0.319	
Serine	0.181	0.179	

Average amino acid composition of goat and cow milk, as published in official USDA tables, shows higher levels of 6 of the 10 essential amino acids: threonine, isoleucine, lysine, cystine, tyrosine, valine in goat milk are given in Table 4 [6,69]. 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. 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) [6,106]. Overall, adult daily dietary nutrient recommendations for essential

amino acids would be met equally or exceeded by a 0.5 l goat milk consumption compared to cow milk [6,107].

A much overlooked component in goat milk is its fat or lipid content. Average goat milk fat differs in contents of its fatty acids significantly from average cow milk fat [25], 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). Average fatty acid^a composition (g/100g milk) in lipids of goat and cow milk are given in Table 5 [6,69]. Three of the MCT (C6–C14) have actually been named after goats, because of their predominance in goat milk [6].

Table 5. Average fatty acids composition (g/100g milk) in lipids of goat and cow milk

	Goat milk	Cow milk	Difference (%) for goat milk
C4:0 butyric	0.13	0.11	
C6:0 caproic	0.09	0.06	
C8:0 caprylic	0.10	0.04	
C10:0 capric	0.26	0.08	
C12:0 lauric	0.12	0.09	
C14:0 myristic	0.32	0.34	
C16:0 palmitic	0.91	0.88	
C18:0 stearic	0.44	0.40	
C6-14 total MCT	0.89	0.61	+46
C4-18 total SAFA	2.67	2.08	+28
C16:1 palmitoleic	0.08	0.08	
C18:1 oleic	0.98	0.84	
C16:1-22:1 total MUFA	1.11	0.96	+16
C18:2 linoleic	0.11	0.08	
C18:3 linolenic	0.04	0.05	
C18:2-18:3 total PUFA	0.15	0.12	+25

aMCT: medium chain triglycerides; SAFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

1.3. The Importance of Goats' Milk and Products

In recent times goat farming is gaining in importance in the world. Factors that the effective in this the production of goats' milk and its processing constitutes an economic activity of increasing importance due to high nutritional interest of goats' milk, as it provides high quality protein, fat, carbohydrates, vitamins, and several minerals, such as iron, calcium, and phosphorus [82,108,109,110,111,112].

Especially sheep and goat edible products (mainly meat and dairy products) have interesting characteristics in their levels of flavour, taste, aromas and leanness as well as the specific composition of fats, proteins, amino and fatty acids. Their quality is very much linked to historical and cultural uniqueness right through the production, marketing and consumption chains [116]. It is a source of proteins of excellent quality, thanks to the proportion of essential amino acids they provide [11,113]. Goat milk is also highly digestible and the biological value of its proteins is superior to that of cow milk proteins [11,114,115]. Goat milk proteins are similar to the major cow milk proteins in their general classifications of α -, β -, κ -caseins, β -lactoglobulin, α -lactalbumin, but they differ in genetic polymorphisms and their frequencies in goat populations [6,116,117,118]. The presence of the α_{s1} -casein trait has been studied much in recent years, when it was discovered that it has six different types, A, B, C, E, F and "null" in goat milk. In cow milk, α_{s1} -casein is the

major α_s -casein. The "null" type or absence in some goat milk means that in different goats the major (α_s -casein is the α_{s2} -casein variant, but which has different digestibility and cheese making properties [6,119]. The differences in genetic types are due to amino acid substitutions in the protein chains, which in turn are responsible for the differences in digestibility, cheese making properties and flavors of goat milk products [6,120], but the amino acid substitutions also enable the detection of even small amounts of adulteration with cow milk [6,121,122]. Furthermore, 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 [80,123]. Mowlem [124] and Sanz-Sampelayo et al. [125] reinforced the claim of these benefits [126].

The production of cheese from goats' milk has a very long history and is an important source of protein for people in several countries [36,37]. In the last decade, there has been an increased interest for goat milk production and its conversion to value added products as well as a renewed interest in goat milk as an alternative milk source for people with cow milk intolerance [23,127]. In some developing countries, goat milk provides a principal source of animal protein, calcium and phosphorus to human nutrition. Goat milk is also used as a

substitute to cow milk for those who suffer from cow milk allergy [80,92,128].

Goat milk has played a very important role in health and nutrition of young and elderly. Goat milk has also been known for its beneficial and therapeutic effects on the people who have cow milk allergy. These nutritional, health and therapeutic benefits enlighten the potentials and values of goat milk and its specialty products. The chemical characteristics of goat milk can be used to manufacture a wide variety of products, including fluid beverage products (low fat, fortified, or flavored) and UHT (ultra high temperature) milk, fermented products such as cheese, buttermilk or yogurt, frozen products such as ice cream or frozen yogurt, butter, condensed/dried products, sweets and candies. In addition, other specialty products such as hair, skin care and cosmetic products made from goat milk recently have gained a further attention. Nevertheless, high quality products can only be produced from good quality goat milk. The quality milk should have the potential to tolerate technological treatment and be transformed into a product that satisfies the expectations of consumers, in terms of nutritional, hygienic and sensory attributes. Taste is the main criteria used by consumers to make decisions to purchase and consume goat milk and its products. Typical goat taste is considered as a quality component in certain goat cheese products. Farmers can produce more value-added products for the economic sustainability of their business and the dairy goat industry in general [126].

According to Park [80] α -lactoglobulin is the major whey protein of cow milk, not found in human breast milk and mostly responsible for cow milk allergy. Although some caprine milk proteins have immunological cross reactivity with cow milk proteins, infants suffering from cow milk allergy symptoms were reportedly cured by goat milk therapy. Cow milk allergy is considered a common disease with a prevalence of 2.5% in children during the first 3 years of life, occurring in 12–30% of infants less than 3 months old, with frequency as high as 20% in some areas [6], where treatment with goat milk resolved between 30 and 40% of the problem cases. According to Park [80] and Jandal [123] goat milk is prescribed by many doctors for children who are sensitive to cow milk, and is an alternative for people who are allergic to cow milk. The author found that approximately 40% of all patients who are sensitive to cow milk proteins tolerate goat milk proteins and it 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 [80]. These patients may, in the future turn more to goat milk and its products to solve their problems. Low α_{s1} -casein content and β -lactoglobulin easier to digest cow's milk because of the feature is small compared to the allergen. Other milk, goat milk is also generally contain less pesticide and composition of microorganisms and also increases the importance of being close to mother's milk. [110,129].

In recent years, goat milk and its products have become more popular in the United States (US), and are considered as specialty products [88,92,93]. In the United States, goat cheese is one of the fastest growing cheese categories in today's specialty cheese market [92]. Goats

produce only approximately 2% of the world's total annual milk supply [87,130]. However, their contribution to nutritional and economic wellbeing of mankind is tremendous in many parts of the world including developing and tropical countries. Goat milk differs from cow or human milk in higher digestibility, distinct alkalinity, higher buffering capacity, and certain therapeutic values in medicine and human nutrition [71,80,87,131,132,133]. Some studies revealed that goat milk [5,12,134] can be considered as a proper alternative to human milk due to hypoallergenic properties of its proteins [5]. Because of problems of the affliction of people with cow's milk allergies and other gastro intestinal ailments, goat milk products are demanded. This demand is also growing because of a greater awareness of problems with traditional medical treatments for such afflictions, especially in developed countries [6,135]. Besides, certain therapeutic properties in human nutrition, such as a better utilization of fat and mineral salts in individuals suffering from malabsorption syndrome, are attributed to goats' milk [4,136]. Goats' milk contains also free taurine, one of the final metabolic products of sulphur containing amino acids [4,65], which may have several biological functions: modulator of growth [4,137] and of neuronal activity [4,138,139,140,141]; conjugation of bile salts [4,142]; regulation of osteoblast metabolism [4,143]; protection of cells against various types of injury and prevention of cardiovascular damage [4,144]; treatment of fatty liver of children [4,145]. Thus, due to the unavailability of cow milk products, goat milk and its products are important daily food sources of protein, phosphate and calcium in underdeveloped countries [71,77,87]. β -casein by the high rate of cow's milk, goats' milk, low-rate α_{s1} -casein and goat milk contains a high percentage of non-protein nitrogen, fermentation time is very short [110,146].

The use of milk with particular nutritional properties (e.g., goats', mares' and donkeys' milk), alone or in combination with bacterial strains having probiotic properties and/or producing physiologically active metabolites, represents one of the technology options for manufacturing new dairy functional beverages [4,14]. As more and more advantages of goat milk over bovine milk have been discovered, such as easy digestion, special flavor, higher concentration of some nutrients, the demand of goat milk has been fast increasing worldwide and goat milk commands higher price than cow milk. In addition, goat milk is especially suitable for the people with cow milk allergies [6,147]. However, goat milk production is dispersed among farmers with small scale husbandry in many developing countries such as China. It is difficult to control the quality of raw goats' milk and its derived products because even accidental contaminants could happen. The adulteration of goat milk and its products with cheaper bovine milk is also increasing and becomes a serious problem. Accordingly, authentication of species origin of milks is essential to avoid unlawful trading and to assure accurate labeling for the dairy products [147,148,149]. There is more practical significance to research on authentication of Guanzhong and Saanen goat milk, two native species in China. Because the cases of substituting bovine milk for goat milk are also increasing. Thus, it is urgent to explore an online detection method appropriate for China [147]. The functional value of

goats' milk may be further exploited through fermentation by selected microorganisms possessing specific features. A mixed starter comprising *Lactobacillus acidophilus*, *Bifidobacterium lactis* and *Streptococcus thermophilus* has been successfully used for fermentation of goats' milk [4,150], and a high viability of probiotic strains in a fermented goats' milk stored at 4 °C for 10 days has been reported [4,151]. Furthermore, the synthesis of folate from some *Lactic acid bacteria* has been shown to occur during fermentation of goats' milk [4,152], and the anti-atherogenic effects of a goats' milk fermented with the probiotic *Lactobacillus fermentum* ME-3 have been reported in 16 healthy subjects [4,153].

In industrial countries, sheep and goat cheeses are very well recognized by connoisseurs as gastronomic and festive products [126,154]. Nevertheless, the consumer interest in the great variety of goat milk products, especially those of "organic" origin or of traditional labels has seen considerable growth in recent years [126,155]. Goat milk besides other milks is a significant food and nutrient source for people in many countries, up to 55% of all milks produced in one country. However, the apparent daily supplies of animal protein and calcium per person from domestic production, according to world statistics, vary widely between countries, and are mostly deficient [6].

Goat milk should have a mild, neutral and appealing flavor. Park [156] stated that the most important quality standard for goat milk is an acceptable, attractive odor and taste. According to Mowlem [124], goats have had very bad publicity for many years and as a result considerable prejudice against goat products sold in the United Kingdom (UK). He stated that the milk would be described by almost everyone who was not a goat enthusiast as "strong, smelly, salty or sweet". With such a reputation it was almost impossible to persuade anyone to try goat milk, even if offered at no cost. Unfortunately, this is true in many regions around the world. Park [156] added to this by stating that the two biggest barriers in marketing goat milk are negative public perception of "goat like" flavor and seasonal milk production. The origin of this misconception can be traced to the fact that goat milk is sometimes obtained in poor sanitary conditions and that goat milk products are poorly manufactured. Only a widespread teaching of goat milk benefits and good taste can transpose this poor reputation [126].

The popularity of dairy products from goats' milk has shown a gradual increase all over the world due to those properties which differentiate it from other milks and beneficial effects on human health [83,157]. In comparison with cow's milk, goats' milk has a higher concentration of short and medium chain fatty acids and lipoprotein lipase associated with the fat phase [158,159]. Fat is one of the most important components in the technological and nutritional quality of goat milk. Lipids are involved in the sensorial quality of caprine dairy products, as well as in cheese yield per kg of milk and firmness [160,161,162,163]. In addition to their quantitative contribution to energy intake, the different lipid and fatty acid (FA) compounds (e.g., short- and medium-chain saturated, branched, mono- and poly-unsaturated, cis and trans, conjugated FAs) are deemed to be positive or negative factors with respect to the health of

human consumers [163,164,165]. Taken together, these considerations explain the interest of modifying goat milk fat content and FA composition [163]. It is thought that these properties of goats' milk have a determinative effect on the development of the characteristic flavour of goats' milk products [166]. Goats' milk has been described as having higher digestibility, due to reduced dimensions of casein micelles and fat globules and higher proportion of short to medium fatty acids [4-65], and lower allergenic properties [106,136,167,168] than cows' milk [4,169]. The nutritional and health benefits of goat milk are related to a number of medical problems of people, foremost being food allergies with cow milk proteins the dominant food cause [170]. The prevalence of cow milk allergy varies with countries and age of people, but exact data are lacking partly because differential diagnostic methods are difficult to perform in the apparent absence of standardized antigens [171], and because cow milk contains 18 different proteins against which antibodies in animal experiments have been demonstrated [172]. α -lactoglobulin is not present in human milk and has therefore been assumed to be the most offending protein in cow milk, however comparative studies showed no difference between the allergenicity of α -lactoglobulin and caseins [173,174]. Genetic polymorphisms of milk proteins also play an important role in eliciting different degrees of allergic reaction [5,80,175,176].

The cholesterol content of goat milk was reportedly in the range 10±20 mg/100 ml [87,177]. Cholesterol contents of goat, cow and human milks are reported as 11, 14 and 14 mg/100 g, respectively. Mean cholesterol contents of cow milk Cheddar cheese were 105 mg/100 g [69,87] and 100 mg/100 g [87,178], while the range of cholesterol for the Cheddar cheese was 95.6± 100.8 mg/100 g [87,179]. The range of cholesterol concentrations (wet basis) of 15 varieties of US and imported commercial goat milk cheeses was 80±147 mg/100 g [87,180].

Sensory properties of goat cheeses are an important factor for consumer acceptability and marketability of the products. Most sensory and textural attributes of cheeses increase during ripening [156]. Selection, freshness and flavor were listed as the primary reasons for purchasing farmers market cheese [181].

The use of goats' milk as an excellent food source is undeniable [82,126]. Goats' milk is designated for direct consumption or for the manufacture of cheese, fermented milks (e.g. yoghurt) and milk powder [82,86]. Goat milk and its products are now fashionable in some parts of the world, where medical needs and connoisseur interests drive these markets [96]. Goat cheese in the United States has gained popularity among ethnic groups, gourmet and health food lovers, and goat farmers [100,126]. In spite of this fact, the world production of goat milk seems relatively minor when compared with the cow milk market (1.8% vs. 6.9%); nevertheless, goat cheeses are widely consumed in some parts of the world such as France and other Mediterranean countries [50,182].

1.4. Using of Goats' Milk in Food Industry

Production of goats' milk worldwide has increased in recent years [14,58,183,184]. Numerous varieties of goat milk cheeses are produced worldwide, depending on diversity in locality, milk composition and manufacturing

techniques used. Maturation or ripening of cheeses from goat milk and milk from other species is governed by many different factors [88]. These factors are mainly attributed to the nature of physical and chemical changes during ripening, which are also influenced by chemicals, cultures or flavour ingredients added to curd during processing [23,100]. Besides, manufacturing techniques include wide variations in amount and species of organism used in culturing, incubation procedures, and forming or pressing techniques. Variations in aging time and conditions play the most important part in determining the flavor, body, and texture of cheese. Most goat cheeses are made by procedures involving slow coagulation, curd remaining with whey until dipped into molds, and drying of the cheeses before ripening. In addition a new and growing interest in goat milk and goat milk products has occurred around the world, and in recent years, there has been a general increase in the volume of goat milk produced. Urban consumers believe that goat dairy products have a good ecological image, and goat milk and dairy products are not rich in fat, are more digestible, are healthy for many gastrointestinal illnesses, and are less allergenic than cow milk. Consequently, goat milk and goat dairy products have real future economic potentials [53,54,55].

European goat breeding has a strong specialisation for milk production. With 3% of the world goat population, Europe produces more than 2 million tonnes of goat milk annually (which corresponds to at least 17% of the world goat milk production) [29,185]. Goat milk is a typical Mediterranean product traditionally consumed directly or as handmade cheese [11,104]. Production of European goat milk is mainly found in the Mediterranean countries: Greece, France, Spain, Italy, and Portugal. Greece, France and Portugal produce 50% of the goat milk in the European Union [29,185].

Annual milk output in Algeria over the last decade was approximately one thousand million liters, including goats' milk amounting to 13% of the total [58,186]. Goats' cheeses are distinctive Mediterranean products; their quality is closely associated with the territory of production and its traditions. The interactions between pedoclimatic characteristics, autochthonous genetic variations and anthropic components create an environment so specific that it would be extremely difficult to reproduce elsewhere [16,187].

Goats' milk products, especially cheeses and yogurt are very popular in the Mediterranean peninsula, the Middle East, southern Russia and the Indian subcontinent [4,135,188]. Goat cheese was originated in Mesopotamia. The milk was probably made into soft cheese, and then hard, ripened goat cheeses were later developed in the Mediterranean basin countries [100]. There are goat cheeses made from raw and pasteurized milk. In many countries the manufacture of goat cheese from raw milk is prohibited due to food safety issues (e.g. brucellosis). The type of milk used significantly influences the finished cheese [40].

In 2008, the Spanish goat milk production was 514.737 metric tons (mt), 227.399 of which were produced in Andalusia, 99.950 in Canary Islands, 64.512 in Castile-La Mancha, 35.709 in Murcia, 32.212 in Castile-León, 25.608 in Extremadura and the remaining 29.347 mt in other regions [189]. Spain has a population of 1.403.850

milking goats that produce, respectively, 514.737 metric tons of milk per year. The 98.2% of the goats' milk produced are used for cheese production [47,189]. In Spain, the consumption of goat and sheep milk as fluid milk is practically negligible and the manufacture of dairy products other than cheeses (above all yogurt and coagulated milk) is also negligible in quantitative terms; therefore, almost all the goat and sheep milk produced is used for cheese production [189]. Most of the goat industry in Spain is oriented towards milk production, particularly in three regions: Andalusia, The Canary Islands and Castile-La Mancha where 71.1% of the milk goats in the country are concentrated [190]. The cheese with the Protected Designation of Origin (PDO) Ibores is produced in the southwest of Spain. Ibores cheese is a full-fat cheese, produced exclusively with raw milk from goats of the breeds Serrana, Verata, Retinta and crosses there of [191].

The French production of goat milk in 2010 was over 630 million L, 512 million of which being collected by dairies and about 120 million L being produced and processed on farm. The major part of this production is converted into cheeses: about 93.000 tons are produced in dairies and 18.000 tons on farms. 96% of goat milk cheeses produced in France are made from pure goat milk, the rest is made from mixtures of different milks [68]. The consumption of UHT goat milk has increased steadily during the last years in France reaching about 10 million L in 2009. The embryonic ultra-fresh goat milk sector (1700 tons a year) is a very promising segment. Finally, the organic goat dairy sector is still very limited, estimated to 0.2% of the total production of goat milk in France [68,192].

In Norway, the production of quark type cheeses from goat milk has increased in recent years. However, goat milk with a particularly strong rancid and tart flavour is unacceptable as raw material for the production of quark cheeses [163].

Sheep and goat milk, in Greece, is mainly used in dairy industry for the production of Feta cheese and other traditional PDO cheeses which must be produced exclusively by sheep and goat milk from animals of native breeds only [66].

Goat milk production in Brazil has improved since the 1990s, and it is considered an important animal product to be exploited as a commodity. Despite this development, the goat milk industry in Brazil is still characterized by small scale farmers, with low daily production (around 80 L) that complicate the logistics of the dairy industry in terms of planning a proper routine for collection and processing [193,194,195].

In southern Italy, a typical and traditional cheese manufactured from goat milk is Cacioricotta cheese [23].

Oggtt is dried fermented goat milk that belongs to the group of dairy products, made by a process involving lactic acid fermen fermentation, which is popular in Bedouin areas of Saudi Arabia and Arabian Gulf countries. Oggtt is basically a hard cheese like product that is considered stable and safe dried fermented milk. It is mainly produced by Bedouins during the spring season when milk is produced in excess amounts [196,197,198].

Milk production from goats in South Africa has increased over the last two decades and projects aimed at promoting goats' milk production by householders and

small-scale farmers are underway [199]. In South Africa, goats' milk is produced by many small scale milk producers and processed into various types of cheeses [36,200].

Obtained by the families of small farmers in our country, goat milk cheese, yogurt, butter, and these products are used in the construction are sold in public markets. However, cow's milk mixed with goats' milk than milk products marketed to businesses [201,202].

The proportion of goat and sheep milk processed into cheeses and yoghurts is higher in comparison to cow milk [154]. Since 5000 B.C. the nutritional and health values of fermented milk and beverages were described [203]. As a process, fermentation consists of transformation of simple raw materials into a range of value added products by utilizing the phenomenon of growth of microorganisms and/or their activities on milk. According to Loewenstein et al. [40], flavor is the most important quality of milk in general, especially in goat milk, for its utilization in the production of consumer products. In the manufacture of some varieties of cheese a relatively strong "goat like" flavor is preferred, but for other products the absence of characterizing flavor is favorable [126].

Correia et al. [204] agreed, concluding that goat milk ice cream has a softer texture and specific melting characteristics. Chakka is a concentrated product obtained after draining the whey from dahi (fermented milk product) [126,157]. Mixing Chakka with sugar and other condiments results in Shrikhand, a very popular and traditional dessert in Western India [203].

Pandya and Ghodke [155] compared the chemical, physical and organoleptic qualities of ice cream made from cow, goat and sheep milk for their suitability for ice cream production. Goat milk produced the most acceptable ice cream followed by cow milk.

Jandal [123] and Haenlein [6] noted that there is few data available on products such as butter, frozen yogurt, and the manufacture of fluid goat milk products such as low fat, fortified or flavored milks, cultured products such as buttermilk or yogurt, frozen products such as ice cream, condensed milk and dried milk products. There is a lack in goat milk research and this needs more attention. However, some research on dairy goat products has been reported recently [78,126,156,206]. Pandya and Ghodke [155] also reiterated that there is a scarcity of publications on the manufacture of different products from goat milk, probably because of the much greater volume of cow milk, making them more suitable for efficient commercial interest compared to goat milk. However, Park and Guo [78,205] and Pandya and Ghodke [155] described various goat milk products, including dry whole milk, dried granulated milk, maize meal with goat milk, condensed goat milk, fruit yogurt, tvorog (full cream, strawberry, garlic and "French-style") soft cheese, blue cheese and hard cheese besides cream, butter and butter oil, cultured goat cream butter, ice cream, whey protein concentrate and evaporated milk, Indian traditional products like Chhana, Paneer and Ghee, and Turkish butter from goat milk like Yayik [126]. Jandal [155] reminds us of some aspects that differ from goat, sheep and cow milk: goat and sheep milk is white compared to cow milk, which is yellowish because of the presence of carotene [126]. Goat milk may have a stronger flavor than sheep and cow milk, due to short-chain fatty acids as a result of improper

handling. Goat milk is slightly alkaline in nature while cow milk is slightly acid. Besides, goat milk has higher proportions of short-chain fatty acids such as caproic, caprylic and capric acids than sheep milk. According to Mowlem [124], in the UK, from 15 to 20 million L of goat milk are processed for consumption each year, of which 60% are for cheese, 20% for fluid milk, 10% for yogurt, and the rest for butter, cream and ice cream. One of these products is a range of cartoned milk for drinking that includes whole, skimmed, semi-skimmed and UHT milk [126].

Goat milk whey has higher levels of α -lactalbumin [155], but is often discarded, or given to animals as nutritional supplement, and little information on it is available. However, presently there are many products made from whey goat milk, among them are whey goat milk flavored beverage, tablets (chewable), whey protein concentrate, and athletic supplements.

2. Conclusion

Geographical conditions deteriorating due to global warming, the goat industry is probably further increase the importance of the future. In addition, goat milk is produced for human health and nutrition of dairy products in terms of features, the less valuable it is clear that the positive. The production of quality goat milk through professional breeding programs can be rewarding, profitable, pleasant and successful. Although goats have been the most defamed domesticated animal in many countries, it has played an important role in human nutrition, wellbeing and survival around the world. Human had to give more importance to their health and nutritional situation with increasing environmental pollution and stress in their life. So, recently it is watched that there has been increasing demand to foods that has functional foods. Functional foods can be defined as foods that have positive effects on the health. An important development in this regard has been in goats' milk mixed products. Therefore the goat milk industry will be virtually dependant on the establishment of high producing dairy goat herds, production of high quality milk, improved and carefully controlled product manufacturing, packaging, storage and distribution techniques. Combined with positive slogans common sense of the organic and health sunulabilme high potential markets. In fact, these slogans are common in many developed countries and markets its products in the goat began to obtain.

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