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Small Ruminant Research 51 (2004) 155–163

Small Ruminant Research

www.elsevier.com/locate/smallrumres

Goat milk in human nutrition

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Abstract

Goat milk and its products of yoghurt, cheese and powder have three-fold significance in human nutrition: (1) feeding more starving and malnourished people in the developing world than from cow milk; (2) treating people afflicted with cow milk allergies and gastro-intestinal disorders, which is a significant segment in many populations of developed countries; and (3) filling the gastronomic needs of connoisseur consumers, which is a growing market share in many developed countries. Concerning (1), very much improvement in milk yield and lactation length of dairy goats, especially in developing countries must be accomplished through better education/extension, feeding and genetics. Concerning (2), little unbiased medical research to provide evidence and promotional facts has been conducted, but is very much needed to reduce discrimination against goats and substantiate the many anecdotal experiences about the medical benefits from goat milk consumption, which abound in trade publications and the popular press. Goats have many unique differences in anatomy, physiology and product biochemistry from sheep and cattle, which supports the contention of many unique qualities of dairy goat products for human nutrition. Concerning (3), a few countries like France have pioneered a very well-organized industry of goat milk production, processing, marketing, promotion and research, which has created a strong consumer clientele like in no other country, but deserves very much to be copied for the general benefit to human nutrition and goat milk producers. The physiological and biochemical facts of the unique qualities of goat milk are just barely known and little exploited, especially not the high levels in goat milk of short and medium chain fatty acids, which have recognized medical values for many disorders and diseases of people. The new concept of tailor making foods to better fit human needs has not been applied to goat milk and its products so far, otherwise the enrichment of short and medium chain fatty acids in goat butter, and their greater concentration compared to cow butter, could have become a valued consumer item. Also revisions to human dietary recommendations towards admitting the health benefits of some essential fats supports the idea of promoting goat butter. While goat yoghurt, goat cheeses and goat milk powder are widely appreciated around the world, goat butter is not produced anywhere commercially in significant volume.

Keywords: Goat milk; Nutritional value; Short and medium chain fatty acids; Cow milk allergy; Goat cheese; Goat milk powder; Goat butter

1. Introduction

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 (Gruner and Chabert, 2000; Boyazoglu and Morand-Fehr, 2001; Haenlein and Fahmy, 1999; Haenlein, 1992, 2001; Morand-Fehr and Boyazoglu, 1999; Rubino et al., 1999). This importance is also reflected in the largest animal number increase for goats during the last 20 years (FAO, 2001) (Table 1) and the largest increase in goat milk production tonnage compared to other mammalian farm animals. Milk production of goats is likely to be much greater

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proteins against which antibodies in animal experiments have been demonstrated (Hanson and Mansson, 1961). β-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 β-lactoglobulin and caseins (Buergin-Wolff et al., 1980; Taylor, 1986). In actual clinical skin prick-tests on 21 adult and 13 infant patients with suspected cow milk allergies, α-lactalbumin caused the most positive skin reactions. Ten of the 13 infants showed positive reactions, while only 5 of the 21 adults reacted (Kaiser, 1990). Of these 5 adults, only one had a weak IgG-titer (ELISA) against α-lactalbumin. However, seven of the infants showed positive RAST tests against whole milk with different levels of IgG-titers against any or all five major milk proteins. The highest titer of 1:3200 was found against α-s-casein and β-casein in an infant 2.5 years old, which was treated against problems of resorption with a hyposensibilization therapy. Generally, IgG-titers were higher against caseins than against whey proteins.

Cow milk allergy is considered a common disease with a prevalence of 2.5% in children during the first 3 years of life (Businco and Bellanti, 1993), occurring in 12–30% of infants less than 3 months old (Lothe et al., 1982), with an overall frequency in Scandinavia of 7–8% (Host et al., 1988), even as high as 20% in some areas (Nestle, 1987), and reported in Italy in 3% of children under 2 years of age (Bevilacqua et al., 2000). Treatment with goat milk resolved between 30 and 40% of the problem cases, and in one particular study 49 of 55 treated children benefited from treatment with goat milk.

The wide variety of genetic polymorphisms (Grosclaude, 1995) of the different caseins and whey proteins adds to the complexity of the cow milk allergy situation and difficulty to determine which protein is mainly responsible for an allergic reaction. However, it has now been shown that this genetic protein diversity may actually help identify which protein is the allergen, if genetic polymorphisms of milk proteins are specifically used for clinical tests (Bevilacqua et al., 2000). Guinea pigs had allergic reactions to goat milk with α-s-1-casein, similar to cow milk, which only has this protein polymorph, and which may explain the commonly found cross-immune reaction between cow milk and some goat milk. However, guinea pigs fed goat milk without this polymorph but instead with α-s-2-casein showed only in 40% an allergic reaction, which lead to the conclusion that goat milk lacking α-s-1-casein is less allergenic than other goat milk.

For goat breeding programs, this new knowledge could be a challenge and rewarding, especially since selection for or against α-s-1-casein is now practiced in some countries, because of differences in cheese yield and renneting (Remeuf, 1993; Moioli et al., 1998). Goat milk with the genetic trait of low or no α-s-1-casein, but instead with α-s-2-casein, has less curd yield, longer rennet coagulation time, more heat lability, and weaker curd firmness, which also may explain the benefits in digestibility in the human digestive tract (Ambrosoli et al., 1988).

Goat milk as a substitute for cow milk was studied in 38 children during a 5 months period (Mack, 1952). The children on goat milk surpassed those on cow milk in weight gain, height, skeletal mineralization, and blood serum contents of Vitamin A, calcium, thiamin, riboflavin, niacin and hemoglobin. Similar findings were obtained in studies with rats (Park et al., 1986). In French clinical studies over 20 years with cow milk allergy patients the conclusion was that substitution with goat milk was followed by "undeniable" improvements (Sabbah et al., 1997). In other French extensive clinical studies with children allergic to cow milk, the treatment with goat milk produced positive results in 93% of the children and was recommended as a valuable aid in child nutrition because of less allergenicity and better digestibility than cow milk (Reinert and Fabre, 1997; Fabre, 1997; Grzesiak, 1997).

In Spanish studies with rats, which had 50% of their distal small intestine removed by resection, simulating the pathological condition of malabsorption syndrome, the feeding of goat milk instead of cow milk as part of the diet resulted in significantly higher digestibility and absorption of iron and copper, thus preventing anemia (Barrionuevo et al., 2002). Also in these studies, the utilization of fat and weight gain was improved with goat milk in the diet, compared to cow milk, and levels of cholesterol were reduced, while triglyceride, HDL, GOT and GPT values remained normal (Alferez et al., 2001). It was concluded that the consumption of goat milk reduces total cholesterol levels and the LDL fraction because of the higher presence of medium chain triglycerides (MCT) (36% in goat milk versus β-, κ-caseins, β-lactoglobulin, α-lactalbumin, but they differ in genetic polymorphisms and their frequencies in goat populations (Martin, 1993; Grosclaude, 1995; Jordana et al., 1996). The presence of the α-s-1-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-s-1-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-s-2-casein variant, but which has different digestibility and cheese making properties (Remeuf, 1993). 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 (Rystad et al., 1990), but the amino acid substitutions also enable the detection of even small amounts of adulteration with cow milk (Aschaffenburg and Dance, 1968; Amigo et al., 1989). In a study of κ-casein digestion, 27 differences in amino acid sequence between cow and goat milk casein macropeptides were found (Mercier et al., 1976). Peptides formed from goat milk casein by proteases tasted much less bitter than those from cow milk casein (Pelissier and Manchon, 1976). Casein micelles, the form of casein molecule suspended in goat milk, also differ markedly from cow milk in less complete sedimentation rate, greater β-casein solubilization, smaller size of micelle, more calcium and phosphorus, less solvation, and low heat stability (Jenness, 1980).

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 (Posati and Orr, 1976) (Table 3). 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) (Barrionuevo et al., 2002). Overall, the 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 (NRC, 1968).

Table 3
Average amino acid composition (g/100 g milk) in proteins of goat and cow milk (Posati and Orr, 1976)

	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	

4. Comparative fat composition of goat milk

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 (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) (Table 4). Three of the MCT (C6–C14) 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, hyperlipoproteinemia, 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

Willett and Stampfer (2003) clearly states that "some fats are healthy for the heart".

5. Other unique components in goat milk

There are a number of unique physiological and anatomical differences between goats and cows which translate into differences in composition of goat milk and its products (Haenlein, 1992, 1996, 2001). This was already recognized by the Goat Milk Task Force of the National Conference on Interstate Milk Shipments (NCIMS, USA) (Atherton, 1983) and lead to important decisions by this governing body of the US dairy industry towards setting separate standards for goat milk from cow milk for butter fat content minimum, solids-not-fat content, somatic cell count maximum, method for only nucleated cells in milk, lower freezing point level, different natural inhibitor test, different milk pasteurization test, validity of brucellosis ring test, detection of cow milk in goat milk, all of which had to insure fair market quality control regulations and practices for goat milk producers. Further comparative differences between goat and cow milk in contents of enzymes, minerals, vitamins, miscellaneous constituents and physical properties have been reviewed in detail (Jenness, 1980; Haenlein, 1980, 1996, 2001).

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