CPQ Nutrition (2018) 1:1
Review Article

CIENT PERIODIQUE

Goat Milk or A2 Cow Milk to the Rescue, A Review

Dr. George Haenlein, F. W.

Department of Animal & Food Sciences, University of Delaware, Newark - DE19717 USA

***Correspondence to:** Dr. George Haenlein, F. W., Department of Animal & Food Sciences, University of Delaware, Newark-DE19717 USA.

Copyright

Received: 26 April 2018

Published: 09 May 2018

Keywords*: Dairy Goats; Cow Milk Allergy; Alpha-s-2 Casein Milk; A2 Beta Casein Milk*

Abstract

The worldwide distribution of goats was discussed leading to the justifiable assumption that more people drink goat milk or eat their products than any other milk after weaning from human nursing. Goats have had a superior population growth rate in numbers compared to other milk producing domestic animals, especially in the developing countries with large people population increases and high rates of undernutrition and malnutrition. Goat farming, especially with milking goats can be quite profitable regardless of country, if intensive types of management are practiced, leading to the prospect that for the increasing people populations there are increasing numbers of milk producing goats available to fight undernutrition and malnutrition. The choice for goat milk has at least three reasons, [1] they are more adapted to severe climate and geological conditions than any other domestic milk producing mammal; [2] they are easier and cheaper kept, especially by women and children than any other domestic milk producing mammal; [3] and their milk has superior nutritional and health qualities compared to the milk of the other domestic milk producing mammals. Thus it can seriously be asked why does goat milk matter? And the call for alternative milks meant that the US Board of Health definition of milk had to include alternative kinds or sources of milk.It also called for research to identify reasons why alternative milks such as goat milk are tolerated by allergy afflicted people, and the testing of milk for genetic variations was started. Soon the different proteins, alpha, beta, kappa, lactoglobulin, etc. were identified and many genetic mutations were recognized.

The logical next step has been to translate this new knowledge into the practice of milk production from cows or goats or even whole herds of them. And this actually is happening with the advent of so-called A2 cow milk or alpha-s-2 goat milk coming to the rescue of people with gastro-intestinal afflictions when drinking traditional milk or with allergy reactions.

Introduction

Globally considered goats are found on each continent except in the Antarctic, and they are giving milk to man on each continent except in the Antarctic. This is in contrast to other animals producing milk for human consumption, which when ranked by numbers globally are: dairy cows (*Bos taurus*), but they have difficulty living in desert and mountainous countries; then there are sheep, but they have been kept mainly for wool and meat production, water buffaloes are not found nor milked outside of India, Southeast Asia and Italy, Brahma-Zebu(*Bos indicus*) cattle milk production is limited to Brazil and Central America, Yak (*Bos gruniens*) are milked only in the high altitude mountains of Tibet and Mongolia, camels are only milked in desert countries, horses and donkeys have been milked in Mongolia, Bulgaria and on specialty farms in Europe, Egypt, Chile, moose are milked on a resort farm in Northern Russia, and reindeer produce milk for people in a few arctic regions of Siberia and Finland, while the South American camelids like llamas und Alpaca have never produced milk for man nor have any other mammalian species there before the time of Columbus, and which is a very strange situation, that people like the Incas, Mayas, Aztecs, who were very advanced technologically and apparently also very athletic, but lived without any milk or dairy products in their diet, contrary to the belief of health authorities in Western countries stating that about 1,000 mg calcium is a daily dietary requirement of adult humans and which can be obtained best from three glasses of milk.

Worldwide goats have reached the 1 billion population size due to tremendous percentage increases of more than 50% more goats during the last 40 years, especially in Africa and Asia [4]. Their numbers are stagnant in the Americas while slightly decreasing in Europe but actually increasing in the Mediterranean region, which reflects dairy goat increases against the numbers around the world, which are more dual purpose, meat, brush and fiber goats. The world statistics of goat milk production also shows a 62% increase from 1993 to 2013 or from 11 to 18 million metric tons, with France, Spain, Turkey and Greece leading in tonnage in that order. As the world people population size increased from 5.5 to 7.2 billion during that same period from 1993 to 2013, it is important and comfortable to know that the large goat number increases in Asia and Africa try to keep pace with the need to feed more people, and that more people actually are exposed to goat milk worldwide than to any other milk.

Economics

Thus the question of economics of dairy goat farming, is it economical to produce goat milk in the face of dairy cows producing so much more milk per animal, this question enters the decision making process. A study of the management of 108 US dairy goat herds in 1978 [1] showed that within a range of 503 to 1,115kg milk per goat per year an income over feed costs from $117.- to $406.- per goat per year was

reported, respectively. Other studies have shown similarly the profitability of goat farming, especially when their management was of the intensive type, such as in the study in Greece [2], where the net return per goat per year was $24.05 for the intensive management type and $7.55 for the extensive type management. In a large study in India [3] the net income per goat per year ranged from $1.80 to $10.00 when milk production per goat per year ranged from 178kg to 595kg, respectively.

Under US conditions and Swiss goat production the break-even producer prices for goat milk were determined to be $0.52 per kg milk at annual production level of 680kg milk compared to $0.26 per kg milk at 1,161kg milk production level [5].Comparing milk whole sale from the farm with retail sales from farm a study in France [6] showed net returns per goat per year of $74.93, when the milk was sold as such from the farm, but $112.00, when the goat milk was processed there into goat cheeses and sold as value added products from the farm, confirming the results of another similar study in Italy [7]. Goat cheeses have seen a great increase in popularity in recent years especially among the more affluent gourmet consumers. Added to the profitability of dairy goat farming per se comes their distinct advantage in areas with harsh climate like the desert in several African and Asian countries, and the steep mountaineous and high altitude conditions of countries like Greece or China.Reviews have discussed all this in greater detail [4,8-11]. An updated review would be welcome, as the dairy goat has changed from its former despised reputation to a valued member of the world dairy industry during the last 40 years. FAO statistics [12] have shown in 2001 that goat milk makes up 55% of all milk in Bangladesh, 51% in Somalia, 24% in Iran, and 16% in Sudan, demonstrating the nutritional value of goat milk in underdeveloped countries with high numbers of undernutrition and malnutrition, e.g. in Bangladesh a person is supplied only 5g protein per day from milk and meat, in Somalia 17g, in Iran 16g, and in Sudan 22g, while the European standards are 60g from milk and meat. Of course the productivity per goat in those countries needs very much improvement, as not all of their goats are being milked, Bangladesh 40kg/goat/year, Somalia 31kg, Iran 15kg, and Sudan 31kg, compared to Spain 121kg and France 400kg.

Nutritional Value

What then is the justification of producing goat milk, if cow milk and goat milk were the same for the nutrition of man? However, they are not in at least two major categories: proteins and lipids in goat milk are very different from those in cow milk. Milk proteins are of the same type in cow or goat milk, but their relative amounts differ greatly, which affects human digestion and cheese yield significantly. Alpha-s-1 casein is the major protein in cow milk but is only found in very low levels or not at all in goat milk, where the polymorphic variant alpha-s-2 casein dominates, which is responsible for a soft curd, easier digestion but also lower cheese yield [12]. Efforts are under way in France and USA to test goat bucks for the presence of the rare alpha-s-1 casein gene and breed selectively against it. Unfortunately, this would eliminate one of the superior values of goat milk for human nutrition, just because cheese yield would be higher. Kappa casein has also been found to differ between cow and goat milk because of amino acid substitutions. Average amino acid composition of goat milk is higher in six of the ten essential acids: cysteine, tyrosine, lysine, valine, threonine and isoleucine. Due to these compositional differences some physical properties of goat milk also differ, such as the size and form of the casein micelle, solubilization, mineral contents and heat stability.

The other major category of differences between the two milks are the lipids. Their contents in milk can vary with different grazing and feeding management in addition to the genetic differences [12], which are principally the short and medium chain fatty acids, that in their higher levels are characteristic for goat milk and some are even named after goats, caproic (C6:0), caprylic (C8:0), capric (C10:0) (SCT). Overall goat milk is generally also higher in contents of medium chain (MCT), monounsaturated, polyunsaturated fatty acids and conjugated linoleic acid (CLA) which is important in human health because of their cardiovascular benefits. In addition, the fat globules in goat milk are mostly much smaller than those in cow milk, which has given goat milk the name of being "naturally homogenized" and which is another digestive advantage in human nutrition.

Health Benefits

SCT and MCT have been used as medical treatments in cases of gastro-intestinal and other disorders including intestinal resection, coronary bypass, gallstones, premature infant feeding, malabsorption syndrome and others, because of their unique ability to provide energy directly in human metabolism instead of being deposited in adipose tissue, while also lowering, limiting and inhibiting cholesterol [13 -16], which is of significant benefit for cardiovascular health. This biomedical superiority of goat milk has not been used in marketing and promotion, but has great potential [17]. In a study in Madagascar [18] with 30 hospitalized children those on goat milk outgained the cow milk children by 9% during the study period. In other studies, in Spain [19] similar results were obtained besides a reduction of total cholesterol levels and the LDL fraction, which was due to the higher provision of MCT from goat milk. In an Algerian study [20] with 64 children with malabsorption syndromes, feeding goat milk caused significantly higher rates of fat absorption in the intestines.

Cow milk allergy in infants can be 8% according to one study [21] or as high as 20% according to another study [22] depending on country, but the use of goat milk is a cure in approximately at least 40% of all cow milk allergy cases [23] or more [24]. Many anecdotal reports [25] exist in support of the value of goat milk for cases with cow milk allergy. A preliminary report [26] of a nutritional study with 38 children drinking daily either 1liter goat milk or 1liter cow milk showed that 22% of the cow milk children were underweight. The goat milk children were superior in skeletal mineralization, blood serum vitamin A, calcium, thiamin, riboflavin, niacin and hemoglobin levels. A study with rats [27] fed either goat or cow milk, showed the goat milk rats grew also significantly better, had higher liver weights, greater hemoglobin iron gain and higher iron absorption. The wide genetic diversity of milk proteins makes it difficult to identify which one is the responsible one in clinical cases of allergy, however studies with guinea pigs [28] have shown that they had allergic reactions when fed alpha-s-1 casein and not if they were fed alpha-s-2 casein. Since alpha-s-1 casein is the dominant protein in cow milk, this may now explain why goat milk is so often a cure for cow milk allergy, since the dominant protein in goat milk is not alpha-s-1 casein but alpha-s-2 casein and goat milk lacking alpha-s-1 casein is less allergenic. This review has been published under the authority of the US Cooperative Extension Service [29].

New Milk to the Rescue

It used to be that according to the standard definition by the Board of Health in each US state milk was defined as being an unadulterated product from cows' udders. Then came the realization that the consumption of fluid milk was not as much as it was recommended by health and nutrition authorities, like 3 glasses per adult person per day. Thus milk as it came from the cow had to be made more consumer friendly and 2% milk, i.e. with only 2% fat, was brought into the market place, changing the purity definition of unadulterated milk for the first time. Thereafter skim milk, i.e. with no fat content, was also entered into the market place. Again the level of consumption of milk of the 3 glasses per day was not achieved. It was realized that there were still many people who either did not want or could not drink milk for reasons of one of two major health problems.

Lactose Intolerance

One was the occurrence of digestive upsets, bloats and stomach pains after drinking any of the now 3 types of milk available. The diagnosis was an inability of adult persons to digest the sugar in milk called lactose and the term lactose intolerance was coined, which was due to the absence of a digestive enzyme in the human adult intestinal tract called lactase. The solution in the market place was to offer either lactose-free milk or lactase supplemented milk, called Lactaid. Thus the unadulterated purity definition of cow milk now had 4 exceptions in the market place: 2%, skim, lactose-free, lactate-supplemented milk. Still consumption of 3 glasses of some kind of milk was lagging.

Cow Milk Allergy

To boost milk consumption there was the option of either adding chocolate, fruit flavors or other flavor substances or to changing the source of milk from cow to some other milk producing domestic animal, as was already practiced in parts of the world outside of the USA, such as goat milk, sheep milk, buffalo milk, camel milk, yak milk and reindeer milk, which all are consumed by some people in regions of the world where cows are not popular or practical for reasons of climate or geography. Thus the purity definition of cow milk had to be changed again by US Departments of Health to include that milk could also be produced by dairy goats besides dairy cows, and soon dairy sheep had also to be added and we now even have in the USA some dairy buffalo herds and dairy camel farms producing their different milk. What these other milks are addressing in the market place is that some milk drinkers still have one other major health problem, i.e. cow milk allergy. Encouraged by several research trials, when cow milk allergic people were changed from cow milk to goat milk drinking, their allergy symptoms of skin rash, ekzema and other dermatitis problems disappeared in 2 out of 3 people. Thus non-allergenic milk can be made available in the market place.

Different Milk Proteins

Research has shown that it is certain proteins in milk that can cause allergic reactions when consumed by humans. Also it is known that milk contains more than one kind of protein, all or any of which can be allergenic. The major proteins in milk, composed of chains of amino acids hooked together, are the cheese yielding three kinds called Casein, specifically alpha, or alpha-s, beta and kappa casein. Each has some variation in their amino acid composition which is identified by chemists with letters and numbers such

A1, A2, A3, B, D, E, F, etc. identifying more specifically which type alpha-s or beta or kappa casein is present in a particular cow's or goat's milk and each may be more dominant in the milk of one cow or goat than in another. This explains why goat milk casein is different from cow milk casein because of differences in their amino acid composition. In fact, most dairy cow milk casein contains the alpha-s-1 casein and little alpha-s-2 casein. Goat milk in comparison often has just the opposite composition, namely mostly alpha-s-2 and little or no alpha-s-1. Cheese making dairy farmers have a preference for alpha-s-1 milk because it produces more cheese from a harder curd in contrast to alpha-s-2 milk which produces a softer curd at a lower yield but with an easier digestibility in human nutrition.

Testing for Milk Protein Differences

Recent research in Italy has found that these two basic differences of amino acid composition between alpha-s-1 and alpha-s-2 casein may be responsible for the allergenicity of cow milk with alpha-s-1 casein in contrast to the non-allergenicity of goat milk with alpha-s-2 casein [28]. US dairy goat owners now can have their dairy goats tested for a small fee for the existence or absence of alpha-s-1 casein in the milk of their goats at the Veterinary Genetics Laboratory of the University of California at Davis under contract with the American Dairy Goat Association [30]. The reason for this testing opportunity is that alpha-s-1 casein has a significantly higher cheese yield than alpha-s-2 casein milk. Unfortunately, the importance of alpha-s-2 casein and its potential non-allergenicity is ignored and so is the market value of this kind of goat milk for people with cow milk allergy affliction.

On the other hand, dairy cow people have recognized the practical aspects of recent research into the characteristics of beta and kappa casein and beta-lactoglobulin genetic variants in cow milk and the correlation with higher cheese yields [31]. The testing for beta casein claims that health benefits are associated with the consumption of A2 beta casein milk compared with A1 beta casein. Testing for kappa casein, A, B or E variants, is also supposed to produce 8% higher cheddar cheese or 12% higher mozzarella cheese yield from BB milk compared to AA or AE milk. Even testing for beta lactoglobulin protein BB is supposed to identify significantly more cheese yield than from milk of the A variant.

Producing New Milks

What is new is that this testing is translated into animal breeding selection practice by farmers creating entire herds of dairy cows or goats with the genetic ability of producing only one or the other type casein in their milk. This new technological testing of the Neogen program is provided widely by the service of the Merck Animal Health Company. However, it does not include testing for alpha-s casein, which the ADGA program does [30]. Thus potentially non-allergenic milk from alpha-s-2 casein milk could be created from entire herds of goats and that is a challenge to dairy goat owners to establish herds of goats having only alpha-s-2 casein in their milk and to have a new advantage in the market place to be of help to allergy sufferers [32].

The amazing fact is that actually a herd of dairy cows now exists in California consisting only of cows with the A2 beta casein producing ability, trying to take advantage in the market place to help people with health concerns to be able to drink more of their recommended 3 glasses of milk per day [33,34]. Thus there maybe now the beginning of "taylor-made" milk, the A2, coming to the rescue of consumers besides the potential alpha-s-2 casein milk for milk allergy sufferers?

Bibliography

1. USDA – DHIA. (1980). Annual report of official dairy herd testing participation. *USDA Publ.,* Washington D.C.

2. Hatziminaoglu, J., Zervas, N. P., & Boyazoglu, J. (1995). Goat production systems in the Mediterranean area: the case of Greece. In: Goat Production Systems in the Mediterranean, A. El Aich et al. (eds.), Wageningen Press, Wageningen, The Netherlands, EAAP Publ, 71, 82-109.

3. Sagar Vidya, & Kanta Ahuja. (1993). Economics of goat keeping. Studies on Goat production and Fodder Resource Management in Rajasthan. Indo-Swiss Goat Development and Fodder Production Project Publ. Jaipur, India, p 58.

4. Haenlein, G. F. W. 2000. Past, present and future perspectives of small ruminant dairy research. *J. Dairy Sci., 84*(9), 2097-2115.

5. Yazman, J. A. (1980). Economics of commercial dairy goat milk production in central Arkansas. Dairy Goat J. 58, 801. In: Extension Goat Handbook, Haenlein, G. F. W., USDA Extension Service Publ., Washington D.C. II (2),1-5.

6. Le Jaouen, J. C., & de Simiane, M. (1986). Breeding systems of dairy goats with cheese making on the farm in France. In: Proceedings IDF Seminar, Production and Utilization of Ewe's and Goat's Milk, Sept. 23-25, 1985, Athens, Greece, Internat. Dairy Fed. Publ., *Brussels, Belgium, Bull. 202,* 5-16.

7. Rubino, R., & Haenlein, G. F. W. (1997). Goat milk production systems: Subsystems and differentiation factors. In: Recent Advances in Goat Research, P. Morand-Fehr, *Centre International Hautes Etudes Agronomiques Mediterraneennes (CIHEAM) Publ.,* Zaragoza, Spain, *25*, 9-16.

8. Haenlein, G. F. W. (1981). Dairy goat industry of the United States. *J. Dairy Sci., 64*(8), 1288-1304.

9. Haenlein, G. F. W. (1996). Status and prospects of the dairy goat industry in the United States. *J. Anim. Sci., 74*(5), 1173-1181.

10. Haenlein, G. F. W. (1997). Alternatives in dairy goat product market. Internat. *J. Anim. Sci., 12*,149-153.

11. Haenlein, G. F. W. (1998). The value of goats and sheep to sustain mountain farmers. *Internat. J. Anim. Sci., 13,* 187-194.

12. Haenlein, G. F. W. (2004). Goat milk in human nutrition. *Small Rumin. Res., 51*(2), 155-163.

13. Tantibhedhyangkul, P. & Hashim, S. A. (1975). Medium-chain triglyceride feeding in premature infants: Effects on fat and nitrogen absorption. *Pediatrics, 55*(3), 359-370.

14. Tantibhedhyangkul, P. & Hashim, S. A. (1978). Medium-chain triglyceride feeding in premature infants: Effects on calcium and magnesium absorption. *Pediatrics, 61*(4), 537-545.

15. Greenberger, N. J. & Skillman, T. G. (1969). Medium chain triglycerides. Physiologic considerations and clinical implications. *New England J. Med., 280*(19), 1045-1058.

16. Barrionuevo, M., Alferez, M. J. M., Lopez Aliaga, L., Sanz Sampelayo, M. R. & Campos, M. S. (2002). Beneficial effect of goat milk on nutritive utilization of iron and copper in malabsorption syndrome. *J. Dairy Sci., 85*(3), 657-664.

17. Babayan, V. K. (1981). Medium chain length fatty acid esters and their medical and nutritional applications. *J. Amer. Oil Chem. Soc., 58*(1), 49A-51A.

18. Razafindrakoto, O., Ravelomanana, N., Razolofo, A., Rakotoarimanana, R. D., Gourgue, P., Coquin, P., Briend, A. & Desjeux, J. F. (1993). Le lait de chevre peut-il remplacer le lait de vache chez l'enfant malnutri? *Lait, 73*(5), 601-611.

19. Alferez, M. J. M., Barrionuevo, M., Lopez Aliaga, L., Sanz Sampelayo, M. R., Lisbona, F., Robles, J. C. & Campos, M. S. (2001). Digestive utilization of goat and cow milk fat in malabsorption syndrome. *J. Dairy Res., 68*(3), 451-461.

20. Hachelaf, W., Boukhrelda, M. Benbouabdellah, M., Coquin, P., Desjeux, J. F., Boudraa, G. & Touhami, M. (1993). Digestibilite des graisses du lait de chevre chez des infants presentant une malnutrition d'origine digestive. *Lait, 73*, 593-599.

21. Host, A., Husby, S. & Osterballe, O. (1988). A prospective study of cow's milk allergy in exclusively breast-fed infants. *Acta Paediatr. Scand., 77*, 663-670.

22. Nestle, W. (1987). Allergy to cow milk proteins. *Med. Enfance, 9,* 163-166.

23. Brenneman, J. C. (1978). Basics of Food Allergy. Charles C. Thomas Publ., Springfield, Illinois, USA, 170-174.

24. Zeman, F. J. (1982). Clinical Nutrition and Dietetics. Callamore Press, D.C. Health & Co., Lexington, Massachusetts, USA, 635 p.

25. Beck, T. (1989). Goat's Milk, the Natural Alternative. T. & M. Beck Publ., Kenwick, Western Australia 6107, (p. 160).

26. Mack P. B. (1952). A preliminary nutrition study of the value of goat's milk in the diet of children. Yearbook, American Goat Society, Inc., Publ., Mena, Arkansas, USA, 106-132.

27.Park, Y. W., Mahoney, A. W. & Hendricks, D. G. (1986). Bioavailabiliy of iron in goat milk compared with cow milk fed to anaemic rats. *J. Dairy Sci., 69*(10), 2608-2615.

28. Bevilacqua, C., Martin, P., Candalh, C., Fauquant, J., Piot, M., Bouvier, F., Manfredi, E., Pilla, F. & Heyman, M. (2000). Allergic sensitization to milk proteins in guinea pigs fed cow milk and goat milks of different genotypes. In: Proceedings 7th International Conference on Goats, Gruner, L. & Chabert, Y., Institute de l; Elevage Publ., Tours, France, II, 874-879.

29. Haenlein, G. F. W. (2017). Why does goat milk matter? - A Review. Nutrition & Food Sciences International Journal, Juniper Publ., Newbury Park - CA., 2(4), 001-004. *Dairy Goat Journal, 95*(4), 46-51.

30. ADGA. (2016). Annual Program. American Dairy Goat Association, Spindale, NC 28160, (p. 24).

31. Neogen Corporation. (2015). Igenity Dairy Heifer Program. Distributed by Merck Animal Health Co., Neogen: GeneSeek Operations Publ., 4131 N. 48th Street, Lincoln - NE 68504, (p. 10).

32. Park, Y. W., Haenlein, G. F. W. & Wendorff, W. L. (2017). *Handbook of Milk of Non-Bovine Mammals* (2nd Ed). Wiley-Blackwell Publishers, Oxford-U.K., (p. 700).

33. Ellie Krieger. (2017). Personal Communication.

34. California Research Foundation. (2017).