# Biochemical characteristics and quality of goat milk

**Jaubert G.**

*in*

**Morand-Fehr P. (ed.).**
**Recent advances in goat research**

**Zaragoza : CIHEAM**
**Cahiers Options Méditerranéennes; n. 25**

**1997**
pages 71-74

# BIOCHEMICAL CHARACTERISTICS AND QUALITY OF GOAT MILK

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## SUMMARY

Goat milk quality depends on a large number of factors which are related to both the animal (breed, number and stage of lactation, health status) and the conditions of production (region, diet, rearing system), and has a predominant influence on the quality of subsequent goat milk products. A significant relationship between flavour and milk composition stressed the effect of animal-related factors (age, stage of lactation and yield) and, to a lesser extent, the type of feeding.

Lipase activity and spontaneous lipolysis play a major role in the development of flavour in goat milk. The volatil fatty acids, and particularly branched-chain fatty acids (4-methyloctanoïc and 4-ethyloctanoïc), have been found the most important compounds for the characteristic goat flavour. Appreciable amounts of 4-methyloctanoïc acid have also been found following the action of natural lipase on caprine milk fat. The technological behaviour of milk (coagulation, acidification and drainage abilities ; heat stability) is primarily affected by the state of the casein micelles and the changes they undergo during treatment of the milk for the purposes of storage or processing.

The genetic polymorphism of caprine κ- and $\alpha_{s2}$-caseins has also been demonstrated and accounts for the existence of 2 variants of κ-casein (Di Luccia *et al.* 1990) and 3 variants of $\alpha_{s2}$-casein. The most important work carried out in the last few years has concerned the genetic polymorphism of $\alpha_{s1}$-casein characterized by marked qualitative heterogeneity resulting in 6 classes of variants, and associated with different levels of protein synthesis.

Nowadays, it is possible to determine the genotype of animals at birth, using the tools of molecular biology and analytical techniques. Such advances open up interesting prospects in terms of improved control of the technological quality of goat milk.

**Keywords** : Goat milk, biochemical characteristics, flavour, caseine, technilogical quality

## INTRODUCTION

The quality of goat milk may be defined as its potential to undergo technological treatment and result in a product which lives up to the consumer's expectations in terms of health (nutritional value), safety (hygienic quality), and satisfaction (sensory attributes).

Thus, the quality of the milk is closely related to its physico-chemical and biological composition, on which its technological capacities are based. Milk quality depends on a large number of factors which are related to both the animal (breed, number and stage of lactation, health status) and the conditions of production (region, diet, rearing system), and has a predominant influence on the quality of subsequent goat milk products.

In this context, the present article is intended to describe recent data which allow a better understanding of variations in the quality of the raw material, goat milk, which are linked to both its physico-chemical characteristics.

## NUTRITIONAL QUALITY

The physico-chemical characteristics of goat milk are currently well recognized. Numerous studies and several syntheses (Jenness 1980 ; Juarez and Ramos 1986) have been carried out in various countries ; some of these describe the biochemical composition in great detail and also the nutritional characteristics (Grandpierre *et al.* 1988 ; Chandan *et al.* 1992).

In nutritional terms, recent studies (Desjeux 1993 ; Fevrier *et al.* 1993 ; Hachelaf *et al.* 1993 ; Razafindrakoto et al. 1993) agree in emphasizing the excellent nutritional value of goat milk (at least equivalent to that of cow's milk), making it a valuable food for inclusion in the diet of children.

## SENSORIAL QUALITY

Among the characteristics of goat milk, flavour is one quality component of particular importance to the cheese producer. Although a goaty flavour is generally required, the desired intensity of the flavour varies according to the type of product, i.e. strong for ripened soft or hard cheeses, slightly strong for white cheese or fermented milk, and slight or nil for goat milk to be drunk as such.

The variability in the specific flavour of goat milk has been demonstrated by several workers (Ronningen 1965 ; Skjevdal 1979 ; Astrup *et al.* 1985 ; Jaubert *et al.* unpublished data) who noted a significant relationship between flavour and milk composition and stressed the effect of animal-related factors (age, stage of lactation and yield) and, to a lesser extent, the type of feeding.

The formation of the specific flavour of goat milk is closely linked to the nature of the various constituents in the milk, and also to biochemical and enzymatic factors. The latter depend on the technological treatments applied to the milk and result in degradation of its constituents. Lipase activity and spontaneous lipolysis play a major role in the development of flavour in goat milk (Chilliard 1982a, 1982b) and the effect of the free fatty acids content has been established (Skjevdal 1979 ; Astrup *et al.* 1985).

Moio *et al.* (1993a and 1993b) used gas chromatography-olfactometry techniques to identify the main neutral volatile compounds responsible for the aroma of fresh milk obtained from the cow, goat, ewe and water buffalo. Ethylbutanoate and ethylhexanoate appeared to be the principal compounds responsible for the odour of goat milk, the latter being differentiated from the milk of ewes and cows by the presence of large amounts of phenylacetaldehyde and benzaldehyde and the absence of phenylethanol. Moreover, higher concentrations of indole, 4-methylphenol and 1-octen-3-ol were found than in cow's milk.

Le Quéré *et al.* (1995) used gaz chromatography, mass spectrometry and olfactometry techniques to identify goat flavour derived from representative extract of cheese. The volatil fatty acids, and particularly branched-chain fatty acids (4-methyloctanoïc and 4-ethyloctanoïc), have been found the most important compounds for the characteristic goat flavour. Appreciable amounts of 4-methyloctanoïc acid have also been found following the action of natural lipase on caprine milk fat (Ha and Lindsay 1993).

## TECHNOLOGICAL QUALITY

From a technological point of view, Remeuf (1992) compared the behaviour of goat milk produced in intensive system, with that of cow's milk. The physico-chemical characteristics of goat milk -especially its low casein content and the specific properties of caprine casein micelles - account for its weaker cheese-making properties.

In fact, the technological behaviour of milk (coagulation, acidification and drainage abilities ; heat stability) is primarily affected by the state of the casein micelles and the changes they undergo during treatment of the milk for the purposes of storage or processing (refrigeration, pasteurization, sterilization, concentration, cheese-making processing - Figure 1). A study of the structural characteristics and composition of caprine casein micelles as a function of pH, temperature and ionic strength (Vesperini-Jaubert 1992) tended to validate the Schmidt model proposed for bovine micelles. However, although the presence of 4 types of casein in the caprine micellar structure has been established (Boulanger *et al.* 1984 ; Ciafarone and Addeo 1984), several authors stress their quantitative and qualitative variability, as well as the effect of casein polymorphism on the cheese-making properties of goat milk (Law and Tziboula 1992 ; Serradilla *et al.* 1992 ; Martin 1993 ; Grosclaude *et al.* 1994).

Chianese *et al.* (1993) analyzed 800 individual milk samples and identified 3 forms of caprine β-casein differentiated by the degree of multiple phosphorylation in the peptide chain. Moreover, the presence of a nul allele suggested by Dall'Olio *et al.* (1989) has been confirmed by Mahé and Grosclaude (1993). Tests carried out on individual milk samples devoid of β-casein have demonstrated their poor ability to coagulate compared with milk samples that have normal contents of β-casein (Chianese *et al.* 1993).

The genetic polymorphism of caprine κ- and $\alpha_{s2}$-caseins has also been demonstrated and accounts for the existence of 2 variants of κ-casein (Di Luccia *et al.* 1990) and 3 variants of $\alpha_{s2}$-casein (Grosclaude *et al.* 1987 ; Chianese *et al.* 1992 ; Bouniol *et al.* 1994) respectively.

The most important work carried out in the last few years has concerned the genetic polymorphism of $\alpha_{s1}$-casein and has been admirably summarized by Grosclaude *et al.* (1994) : this polymorphism is characterized by marked qualitative heterogeneity resulting in 6 classes of variants, and associated with different levels of protein synthesis. Thus, a high level of $\alpha_{s1}$-casein synthesis (variants A, B and C : 3.6 g/l/allele), a medium level (variant E : 1,6 g/l/allele), a low level (variants D and F : 0,6 g/l/allele) and finally a nul level (allele 0) can be identified. Accordingly, there is a difference of about 6 g of $\alpha_{s1}$-casein per litre between the milks derived from two homozygous goats with high or low rate of $\alpha_{s1}$-caseine synthesis.

Comparative studies on the physico-chemical characteristics of goat milks containing high and low levels of $\alpha_{s1}$-casein (Remeuf 1993 ; Pirisi *et al.* 1994 ; Vassal *et al.* 1994) have shown that genotype has a significant effect on casein content, fat percentage and micelle characteristics (size and mineralization). These differences result in diverse technological behaviours and milk with a high level of $\alpha_{s1}$-casein shows a greater aptitude to coagulate and gives a significantly higher yield during cheese processing (+ 10 to + 15 %). A significant effect is also noted in terms of cheese texture and flavour : cheese prepared from milk with

a high $\alpha_{s1}$-casein content is firmer and inclined to have a less pronounced "goaty" flavour (Heil and Dumont 1993 ; Vassal *et al.* 1994).

Nowadays, it is possible to determine the genotype of animals at birth (Leroux *et al.* 1993), and also to establish the casein profile for milk, using the tools of molecular biology and analytical techniques. Such advances open up interesting prospects in terms of improved control of the technological quality of goat milk. Conceivably, the selection of animals will become more accurate and effective. Moreover, the quantitative and qualitative analysis of milk caseins is a means of evaluating the performance of a goat and/or herd and assessing the technological quality of the raw material. This information would allow cheese producers to optimize the processing stage by directing the milk according to its technological potential towards the most suitable forms of processing.

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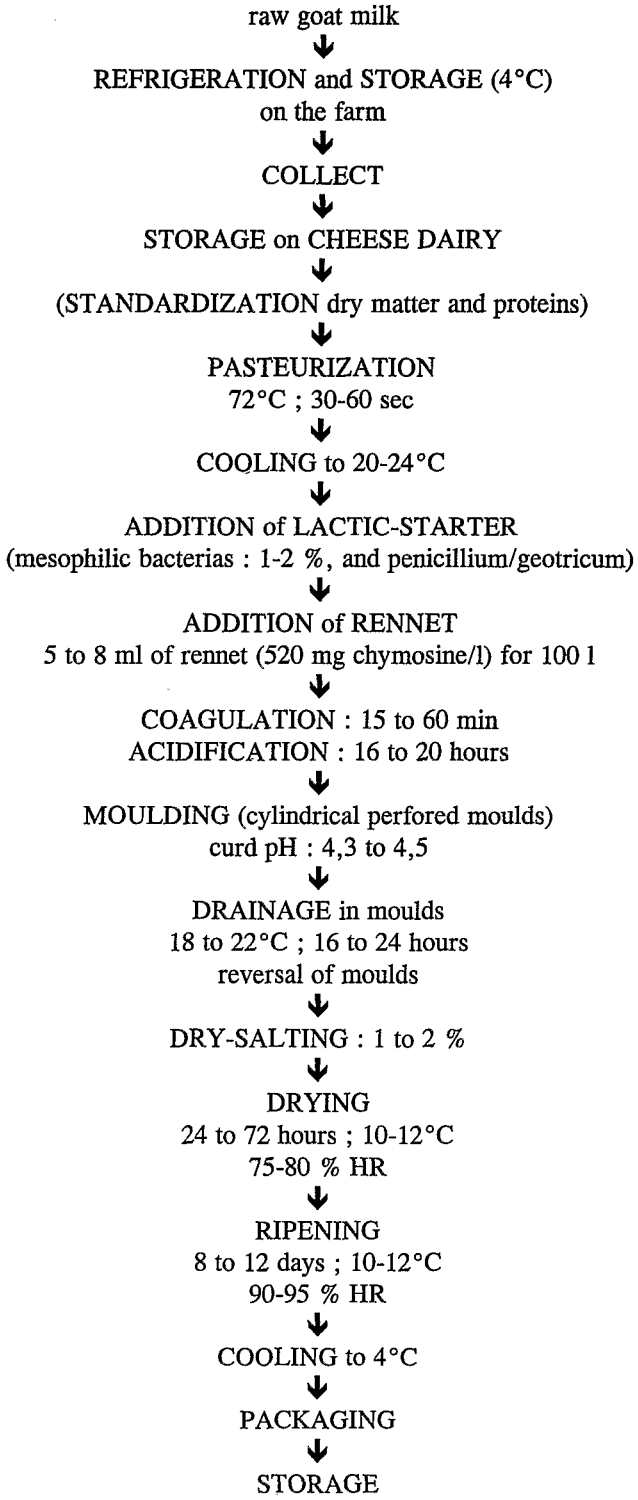


Figure 1. Treatments applied to goat milk for the manufacture of St Maure (French ripened soft cheese)