

## Goat milk and heat treatments

K. Raynal-Ljutovac<sup>1#</sup>, T. Massouras<sup>2</sup> and M. Barbosa<sup>3</sup>

<sup>1</sup>Institut Technique des Produits Laitiers Caprins (ITPLC). BP 49 – 17700 Surgères – France

<sup>2</sup>Agricultural University of Athens – Department of Food Science and Technology

75 Iera Odos Street – 11855 Athens – Greece

<sup>3</sup>Instituto Nacional de Engenharia e Tecnológica Industrial (INETI) – Departamento de Tecnológica das Industrias Alimentares. Estrada do Paço do Lumiar 22 – 1649-038 Lisboa – Portugal

---

### Abstract

Heat stability of goat milk has been investigated on European milk samples from France, Greece and Portugal. A variability of coagulation temperatures was observed and was directly linked to milk composition. Some technological adaptations such as the use of additives can greatly improve heat stability of French goat milk. Furthermore, some steps of the Ultra High Temperature Treatment (UHT, 136 °C/6s) process itself can be detrimental and must be taken into account. It was shown that cold storage (72 h at 4 °C) could impair the stability of goat milk.

---

**Keywords:** Goat milk, heat stability, physicochemical composition, additives, cooling

<sup>#</sup>Corresponding author. E-mail: ketsia.raynal@itplc.asso.fr

### Introduction

Goat milk is more sensitive to high heat treatments than bovine milk. The available reports indicate that pH (Zadow *et al.*, 1983; Ram & Sindhu, 1991; Montilla & Calvo, 1997; Anema & Stanley, 1998), micelle hydration (Thompson *et al.*, 1969), genetic polymorphism of  $\alpha$ -S1 casein (Tziboula, 1997), non-protein nitrogen (Mukherjee *et al.*, 1993), salt balance (Ram & Sindhu, 1991) and ionic calcium (Zadow *et al.*, 1983; Montilla & Calvo, 1997) could be directly or indirectly involved in the heat sensitivity of caprine milk. As goat milk shows great variability in biochemical composition, technological properties and bacteriological quality (Anifantakis & Kandarakis, 1980; Barbosa, 1993; Jaubert & Kalantzopoulos, 1996) depending on genetic factors, environmental conditions, and goat farming practices, heat sensitivities of goat milk can be different according to European countries such as Greece, France and Portugal.

Moreover, conditions of transformation during the Ultra High Temperature Treatment (UHT, 136 °C/6s) process must also be taken into consideration. Besides the use of additive to increase goat milk stability, the UHT process itself can be investigated or more specifically, all the steps prior to the UHT treatment. Besides the effect of heat treatment on colloidal stability, cooling also has negative effects. The most evident effects are solubilisation of colloidal calcium and micellar caseins, especially  $\beta$ -casein. Since cold storage is the most common way of preserving milk at the farm and on arrival in the plant, the time of cold storage must be taken into account in the UHT process as a key step.

### Materials and Methods

Physicochemical characteristics and heat stability of French (F), Greek (G) and Portuguese (P) bulk milk collected by SMEs were evaluated as described in Morgan *et al.* (2003). Goat breeds were Saanen and Alpine in France, indigenous breeds in Greece and Granadina, Serpentina, Alpine and Saanen in Portugal.

Given the fact that most of the milk samples were unstable at 140 °C or 120 °C, the determination of heat coagulation time at a fixed temperature was not possible in the present study. Heat coagulation temperature was measured at a fixed time (1 min), as previously described by Morgan *et al.* (2000). Milk samples (60  $\mu$ L) were sealed in glass-capillary tubes and heat treatment was performed in an oil bath at temperatures ranging from 80 to 140 °C for 1 min. The heat stability (HS) was defined as the maximum temperature within the range 80-140 °C at which the sample was stable during a 1-min treatment. Three replicates were carried out for the measure.

To evaluate the impact of additive and cold storage, the UHT treatment at 136 °C/6s was applied on French skimmed milk before and after storage at 4 °C for 72 h. The additive used were disodium phosphate (3 mM), a mix of phosphate (6 mM) and trisodium citrate (3 mM).

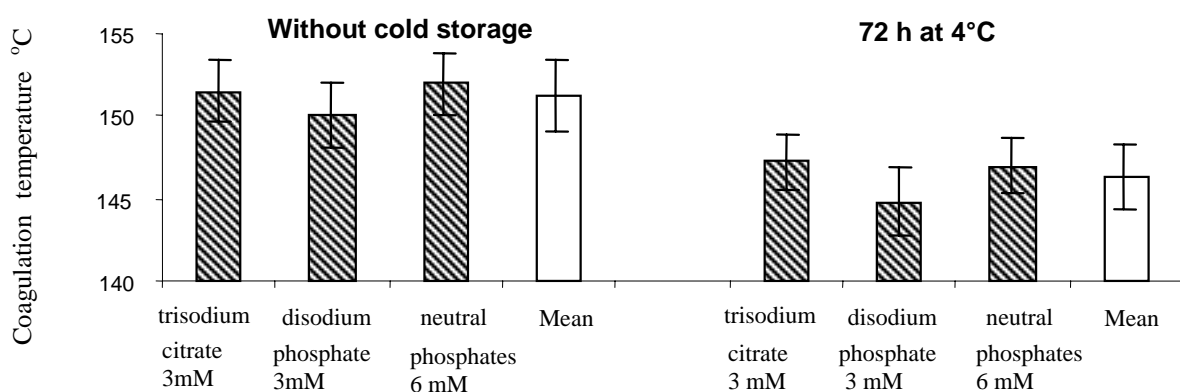
## Results and Discussion

Results concerning heat stability of European goat milk are given in Table 1. Heat stability of Portuguese milk (124.5 °C) was similar to the French one F1 (125.9 °C), and the heat stability of F2 milk was the highest (133 °C). Greek milk had a very low heat stability (92-110 °C). This poor thermal stability could be related to the physicochemical (protein concentrations, low pH linked to microbiological characteristics, data not shown) of these samples due to the fact that maximum heat stability of goat milk occurs at pH 6.9-7.0 (Tziboula, 1997; Anema & Stanley, 1998; Morgan *et al.*, 2001).

**Table 1** Technological aspects of goat milk collected from small and medium enterprises in Greece (G1-G4), France (F1, F2) and Portugal (P)

SMEs		Total solids (%)	Protein (g/kg)	Casein / Protein (%)	pH	Heat stability (°C)
G1	Mean	14.4	38.3	77.3	6.51	92.0
	s.d.	0.3	1.3	3.07	0.1	4.4
G2	Mean	13.8	37.6	78.0	6.55	95.0
	s.d.	0.7	3.0	1.6	0.08	2.6
G3	Mean	13.1	35.0	74.0	6.61	110.0
	s.d.	0.5	2.8	6.11	0.06	3.7
G4	Mean	13.6	36.9	76.2	6.56	105.0
	s.d.	0.3	1.1	2.3	0.45	3.3
F1	Mean	11.8	32.3	73.7	6.63	125.9
	s.d.	0.9	2.4	2.6	0.14	5.6
F2	Mean	11.6	32.6	72.2	6.75	133.0
	s.d.	0.6	1.5		0.10	5.9
P	Mean	12.8	34.9	n.d.	6.59	124.5
	s.d.	0.5	1.6		0.14	6.5

n.d. - not determined



**Figure 1** Impact of cold storage on heat stability

Other factors such as ionic calcium and whey proteins may also play a role in the thermal coagulation of goat milk (Morgan *et al.*, 2000; 2001). A negative impact of cold storage on heat stability, because of increased calcium level during cold storage (Raynal & Remeuf, 2000), may be suggested. The negative impact of cold storage before UHT treatment has been demonstrated for French milk (Figure 1). The use of trisodium citrate greatly improved heat stability of goat milk (coagulation temperature: more than 146 °C compared to 136 °C for fresh milk without additive: 136 °C). Nevertheless, additives do not enable stored milk to support as high a temperature as non-stored milk.

## Conclusion

Due to the low heat stability of goat milk, especially at its natural pH, technological controls (of sanitary criteria in order not to have low pH) and/or technological adaptations are needed when heat treatments are used for the production of goat milk namely, to avoid low pH goat milk with a good control of sanitary criteria, to avoid long time storage at 4 °C before UHT treatment and finally to use some technological additives.

## Acknowledgements

We thank the EU for financial support concerning work on composition of European goat milk in the “cadre” of craft program FAIR CT 98-9598. We also thank the French Ministry of Agriculture and Fisheries for its support in the “Aliment-Qualité-Sécurité” program.

## References

- Anema, S.G. & Stanley, D.J., 1998. Heat-induced, pH-dependent behaviour of protein in caprine milk. *Int. Dairy J.* 8, 917-923.
- Anifantakis, E.M. & Kandarakis, J., 1980. Contribution to the study of the composition of goat's milk. *Milchwissenschaft* 35, 617-619.
- Barbosa, M., 1993. Goat's milk research in Portugal. *Lait* 73, 425-429.
- Jaubert, G. & Kalantzopoulos, G., 1996. Quality of goat milk cheese and other products. 6<sup>th</sup> Int. Conf. on Goats, Beijing, China, 6-11 May, vol. 1, pp. 274-284.
- Montilla, A. & Calvo, M.M., 1997. Goat's milk stability during heat treatment. Effect of pH and phosphates. *J. Agric. Food Chem.* 45, 931-934.
- Morgan, F., Massouras, T., Barbosa, M., Roseiro, L., Ravasco, F., Kandarakis, I., Bonnin, V., Fiskatoris, M., Anifantakis, E., Jaubert, G. & Raynal-Ljutovac, K., 2003. Characterisation of goat milk collected by small and medium enterprises from Greece, Portugal and France. *Small Rumin. Res.* 47, 39-49.
- Morgan, F., Massouras, T., Barbosa, M., Roseiro, L., Ravasco, F., Kandarakis, I., Bonnin, V., Fiskatoris, M., Anifantakis, E., Jaubert, G. & Raynal-Ljutovac, K., 2003. Characterisation of goat milk collected by small and medium enterprises from Greece, Portugal and France. *Small Rumin. Res.* 47, 39-49.
- Morgan, F., Micault, S. & Fauquant, J., 2001. Combined effect of whey protein and  $\alpha_{S1}$ -casein genotype on the heat stability of goat milk. *Int. J. Dairy Technol.* 54, 64-68.
- Morgan, F., Micault, S., Jacquet, F., Bonnin, V. & Jaubert, A., 2000. Study on the compositional factors involved in the variable sensitivity of caprine milk to high temperature processing. *Int. Dairy J.* 10, 113-117.
- Ram, S. & Sindhu, J.S., 1991. Salt balance and heat stability of goat milk as affected by pH. *Ind. J. Anim. Sci.* 61, 753-756.
- Raynal, K. & Remeuf, F., 2000. Effect of storage at 4 °C on the physicochemical and renneting properties of milk: A comparison of caprine, ovine and bovine milks. *J. Dairy Res.* 67, 199-207.
- Tziboula, A., 1997. Casein diversity in caprine milk and its relation to technological properties: heat stability. *Int. J. Dairy Technol.* 50, 134-138.
- Zadow, J.G., Hardham, J.F., Kocak, H.R. & Mayes, J.J., 1983. The stability of goat's milk to UHT processing. *Aust. J. Dairy Technol.* 38, 20-23.