

# Mix Goat and Sheep Yogurt: Development and Product Characterization

Susana Matos, António Pinto, Conceição Castilho, Paula Reis Correia, and António Cardoso Monteiro

**Abstract**—Yogurts are prepared by fermenting milk with bacterial cultures consisting of a mixture of *Streptococcus* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. The main aim of this investigation was to develop a majority goat yogurt, with the addition of sheep milk in order to have a final product with good physicochemical quality properties and sensorial attributes. Four types of yogurts were prepared presenting the following proportion of goat and sheep milk respectively: C100 – 100%; C80 – 80%/20%; C60 – 60%/40%; C50 – 50%/50%. The goat milk was from the Serrana Jarmelista breed and the sheep milk from the Serra da Estrela breed. The inclusion of sheep milk improved attractiveness to consumers, and it also improved the nutritional value of the product, mainly the fatty acid and mineral contents. The C50 yogurt was preferred by 28% of the panellists, followed by the C100 with 16% and the commercial cow yogurt was 40% of preferences.

**Keywords**—Goat, sheep, yogurt.

## I. INTRODUCTION

GOAT and sheep productions are common in mountainous regions, such as the Mediterranean and the Middle East, where other species are not so well adapted to these harsh conditions [1], [2]. The goat productions from native breeds in Portugal are mainly intended for meat production, with slaughter mean weights of 10 Kg live weight. Generally, the milk production is only for feeding the kids, but the goats have a potential to be milked. When milked the goal is to produce cheese like the dairy sheep production, but the market is limited, so new products need to be promoted. Dairy goat products are more adequate to human health, with lower incidence of allergic reactions [3]-[5] and are beneficial to the treatment of other diseases such as gastrointestinal, cardiovascular and stress related diseases [6].

The components of greatest importance in the use of milk as a raw material for the production of yogurt are proteins, lipids, lactose and minerals [7]. Several authors refer that the milk composition of sheep and goats differ, not only in the quantity of their components [8], [9], [2], but also in the type of components, like caseins or micellar structures [10], [3]. So the aim of this work was to know how the mix of goat milk and

sheep milk influence the production of yogurt, to contribute towards optimizing a future development of this product from the milk of native breeds.

## II. MATERIAL AND METHODS

The milk was obtained from the Serrana Jarmelista goat breed and Serra da Estrela sheep through mechanical milking. It was collected from the refrigerator container with an agitator and immediately pasteurized for 30 minutes at 65°C followed by rapid cooling down to 4°C. After the heat treatment the yogurt was produced using goat and sheep milk, according to the four experimental groups in the following proportions of goat and sheep milk: C100 – 100%; C80 – 80%/20%; C60 – 60%/40%; C50 – 50%/50%. The lactic bacteria used in the yogurt production were lyophilized *Streptococcus thermophilus*, *Lactobacillus delbrueckii* spp *bulgaricus*, and a commercial milk powder was also added (12%). The samples of yogurt were placed in hermetically sealed bottles. These were then frozen at -20°C. The total nitrogen was measured by the micro-Kjeldahl method [11]. Protein was calculated as N x 5.38. The fat was determined by the method of Geber [12]. Ash content was determined by dry ashing the samples for 24h at 550°C. Moisture content was determined by drying samples overnight at 105°C [11]. Total solids content was determined by the gravimetric method by drying the samples in an oven at 105°C for 24h [11]; the phosphorus was determined by spectrophotometric UV/VIS, 720nm [13]; calcium, magnesium, potassium, and sodium by the method of flame atomic spectrophotometry at 750nm [14]. Fatty acids were determined by a gas-chromatographic method (GLC), Total titratable acidity was determined by reference [11] method, and the pH by the potentiometric method. The viability of the lactic ferments over time was carried out according to the MRS method [15].

For the sensorial analysis of samples, we used the acceptance test with untrained panellists. The study used 25 tasters who analyzed 5 samples, 4 of those developed in this work and 1 was a commercial natural yogurt made from cow milk. Each panellist gave marks from 1 to 9, where 1 is "Extremely unpleasant" and 9 is "Extremely nice" for the attributes of sweetness, color, aroma, flavor, texture and overall assessment. At the end the question "Which sample did you prefer?" was asked to assess the tasters' overall preference.

The statistical analysis was performed with recourse to the Statistica 5 programme [16], where has determinates the mean,

S. Matos and A. Pinto were with the Escola Superior Agrária de Viseu, Instituto Politécnico de Viseu, Viseu, Portugal.

C. Castilho was with Laboratório de Bromatologia da Faculdade de Farmácia da Universidade de Coimbra.

P. R. Correia and A.C. Monteiro were with the CI&DETS, Instituto Politécnico de Viseu, Viseu, Portugal (corresponding author - phone: +351-232 446 600; fax: +351-232 426 536; e-mail: amonteiro@esav.ipv.pt)

A. C. Monteiro thanks FCT for financial support through project PEST-OE/CED/UI4016/2011.

standard deviation, mode, median, minimum and maximum were determined. The results were analyzed by one-way analysis of variance. Differences between the treatment means were compared at the 5% level of significance using the LSD test. The Kruskal-Wallis test was used to verify the panelists' preferences for the yogurt samples.

### III. RESULTS AND DISCUSSION

The physicochemical properties of all yogurt samples of yogurt are shown in Table I. From the standard deviations obtained, it appears that the results do not differ greatly and are therefore relatively consistent.

For the values of moisture, there is a difference in the average value of goat milk compared with sample C100, being the values 87% and 79% respectively. This inequality is associated with the addition of powdered milk during the yogurt preparation, causing a decrease in water availability and hence lower water content in the product [17]. As sheep milk is added, the value of moisture is even smaller because sheep milk has a higher content of solids, as can be seen in sample C50.

Associated with the loss of moisture is the increase in total solids which is verified in samples C50 and C60, as the amount of added sheep milk increases the dry matter content also increases.

TABLE I

MEANS AND STANDARD ERROR OF CHEMICAL COMPOSITION OF YOGURT 100, 80, 60 AND 50% OF GOAT'S MILK AND SHEEP'S MILK

Chemical composition	C50	C60	C80	C100
Total solids (%)	23.07 <sup>a</sup>	23.84 <sup>a</sup>	21.00 <sup>a</sup>	21.17 <sup>a</sup>
±SE	1.18	2.63	1.72	0.24
Fat (%)	8.20 <sup>a</sup>	8.40 <sup>a</sup>	7.87 <sup>a</sup>	6.93 <sup>b</sup>
±SE	0.2	0.20	0.42	0.61
Protein (%)	8.76 <sup>a</sup>	8.24 <sup>ab</sup>	7.32 <sup>b</sup>	7.98 <sup>ab</sup>
±SE	0.77	0.29	0.18	0.07
Moisture (%)	76.35 <sup>a</sup>	77.89 <sup>b</sup>	77.05 <sup>c</sup>	79.08 <sup>d</sup>
±SE	0.07	0.06	0.43	0.06
Ash (%)	1.71 <sup>a</sup>	1.69 <sup>a</sup>	1.68 <sup>a</sup>	1.77 <sup>a</sup>
±SE	0.06	0.14	0.06	0.14
Acidity (ml/100g)	17.90 <sup>a</sup>	18.33 <sup>a</sup>	18.13 <sup>a</sup>	17.37 <sup>a</sup>
±SE	0.35	0.06	0.15	0.45
pH	4.40 <sup>a</sup>	4.45 <sup>a</sup>	4.35 <sup>a</sup>	4.50 <sup>a</sup>
±SE	0.14	0.07	0.07	0.01

<sup>a, b</sup> Within a row, means without a common superscript letter differ (P<0.05)

The fact that the values for the dry extract are not very consistent, such as fat, protein and ash indicates a possible variation in the constituents of the milk sample due to homogenization. It was expected that if sheep milk were added, the fat, protein and ash should increase, since this milk has a greater amount of these macronutrients [18], [19]. However, this relationship is only observed when comparing the fat in sample C50 with sample C100, because the amount of sheep milk added is greater.

The lack of a considerably high speed homogenization may

be the cause of the discrepancy values. The amount of protein in the sample obtained from C100 was 7.98, which represents a very high value compared to the indicated value of 4.6 [18]. The addition of powdered milk may be the source of these particularly high values.

The Portuguese standard NP-694 [20] stipulates a maximum acidity of 13cm<sup>3</sup>/100g in yogurt produced from cow milk. In this work acidity levels of approximately 18cm<sup>3</sup>/100g were found revealing greater acidification of yogurt made from goat and sheep milk.

In the Table II we verified that the addition of powdered milk increased the contents of calcium, phosphorus and sodium in yoghurts. The value of phosphorus increased considerably tending to increase with the addition of sheep milk, since it has a higher amount of phosphorus [9]. There was also an increase in calcium from sample C100 to sample C50 in part due to the addition of sheep milk.

TABLE II

MEANS AND STANDARD ERROR OF MINERAL AMOUNTS OF CA, NA, MG, K AND P AT YOGURT SAMPLES

Minerals (mg/100g)	C50	C60	C80	C100
Calcium	190.2 <sup>a</sup>	180.5 <sup>b</sup>	179.8 <sup>b</sup>	160.9 <sup>b</sup>
±SE	7.87	4.00	16.25	3.21
Sodium	55.35 <sup>a</sup>	56.49 <sup>a</sup>	58.65 <sup>a</sup>	60.11 <sup>a</sup>
±SE	11.03	1.01	7.91	14.74
Magnesium	17.19 <sup>a</sup>	16.85 <sup>a</sup>	16.32 <sup>a</sup>	15.54 <sup>a</sup>
±SE	5.80	2.69	0.830	16.41
Potassium	155.5 <sup>a</sup>	170.8 <sup>a</sup>	157.6 <sup>a</sup>	162.5 <sup>a</sup>
±SE	43.10	21.75	19.62	50.44
Phosphorus	185.7 <sup>a</sup>	165.9 <sup>a</sup>	152.4 <sup>a</sup>	140.1 <sup>a</sup>
±SE	89.01	14.62	16.04	50.56

<sup>a, b</sup> Within a row, means without a common superscript letter differ (P < 0.05)

In Fig. 1 we can observe the percentage of total saturated and unsaturated fatty acids in the yogurt samples, and would expect yogurt C100 to have lower saturated fatty acids content [19]. However, total unsaturated fatty acids were higher in sheep milk. Thus, in yogurts the percentage of unsaturated fatty acids increases with the addition of sheep milk, which was in accordance with other work [19].

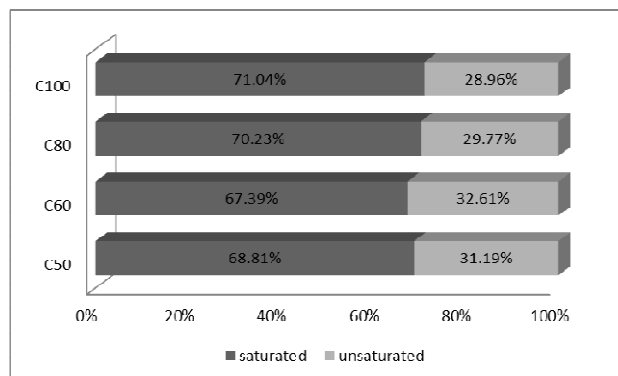


Fig. 1 The percentage of total saturated and unsaturated fatty acids in the yogurt samples

Counting of microbial populations throughout the refrigeration time in Table III, we find that in yogurt made exclusively from goat milk (C100), the number of viable microorganisms on the first day of storage (day 0) is higher:  $6.8 \times 10^9$ CFU/mL versus  $2.6 \times 10^9$ CFU/mL in the sample C50 (Fig. 2), showing it is more favorable to the growth of lactic acid bacteria in C100 yogurt. From this time (Day 0), cellular divisions are inhibited by the lactic acid produced [21], changing from a stationary phase to a phase of death of viable microorganisms, as seen on day 7. On the 7th day of storage an accentuated decrease of viable microorganisms occurs in the C100 sample, approaching sample C50,  $2.9 \times 10^9$ CFU/mL and  $2.0 \times 10^9$ CFU/mL respectively, indicating an unfavorable medium for the growth of the milk culture. Between day 7 and day 20, the number of viable cells remains practically constant in C100 yogurt, while there is a greater reduction in viable microorganisms in the C50 yogurt, possibly due to the presence of the substance inhibiting of the lactic bacteria present in sheep milk.

TABLE III  
COUNT OF MICROBIAL POPULATIONS THROUGHOUT THE REFRIGERATION TIME (CFU/ML)

Days	C50	C100
1	$2.6 \times 10^9$	$6.8 \times 10^9$
7	$2.0 \times 10^9$	$2.9 \times 10^9$
20	$8.9 \times 10^8$	$2.5 \times 10^9$

Fig. 2 shows the evolution of pH during yogurt storage. There appears to be no bacterial metabolic activity in the yogurt by the constancy of pH values in the first 14 days. However, on the 20th day of storage there is a slight increase in pH in all samples, which is more visible in the C100, C60 and C50 samples, indicating the beginning of the yogurt's deterioration.

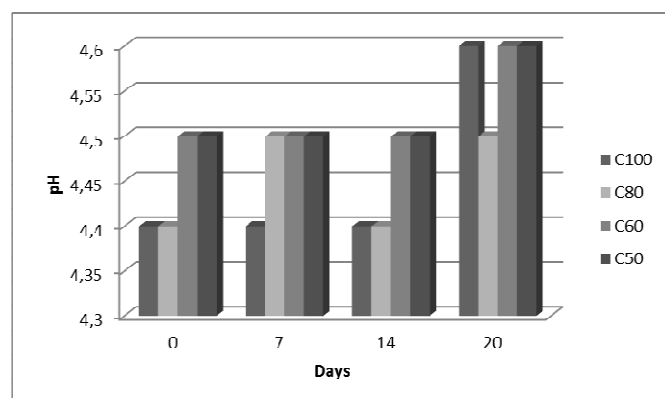


Fig. 2 Evolution of pH during storage

In sensory analysis performed by panellists there were no significant differences ( $P > 0.05$ ) between samples. However, Fig. 3, which shows the preference of the samples identified by the panellists, indicates that the commercial cow yogurt was preferred by 40% of the panellists, followed by the C50 yogurt with 28% of the responses. The C60 and C80 yogurts are the

least selected with 4% and 12% respectively.

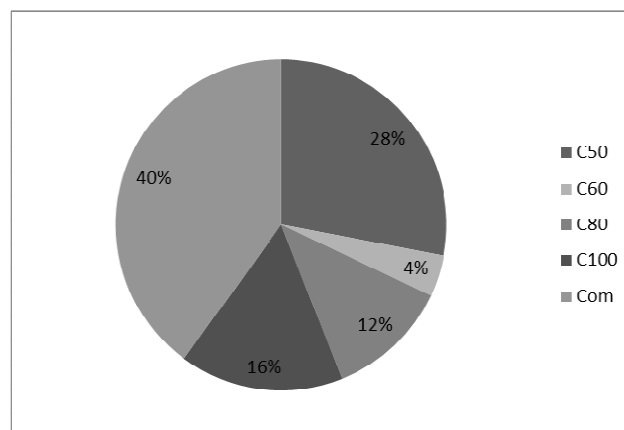


Fig. 3 Preference of the samples identified by the panelists

#### IV. CONCLUSIONS

The preparation of yogurt from goat and sheep milk was shown to be acceptable by the majority of panelists. Nevertheless, further testing is needed to determine which proportion of milk in the mix will maximize acceptance. The addition of sheep milk promotes a significant increase in fat, but tends to increase the proportion of unsaturated fatty acids.

It will be necessary to test other production parameters such as heat treatment, incubation temperature, inoculum percentage for yogurt based on milk mixture, as well as the use of different types of cultures inoculated, particularly those acting on consistency for subsequent improvement of yogurts with higher amounts of goat milk.

#### ACKNOWLEDGMENT

The authors thank to the research center CI&DETS supported by Fundação para a Ciência e Tecnologia. Also thank to Tecnilac.

#### REFERENCES

- [1] Haenlein GFW. About the evolution of goat and sheep milk production. *Small Ruminant Research*, Volume 68: 3-6, 2007.
- [2] Pandya AJ, Ghodke KM. Goat and sheep milk products other than cheeses and yoghurt. *Small Ruminant Research*. 68: 193-206, 2007.
- [3] Haenlein GFW. Producing quality goat milk. *International Journal Animal Science*. Volume 8: 79-84, 1993.
- [4] Saini AL, Gill RS. Goat milk: An attractive alternate. *Indian Dairyman*. 42: 562-564, 1991.
- [5] Zeman FJ. *Clinical nutrition and dietetics*. Callamore Press, Daniel Collamore Heath and Company. Lexington, Massachusetts, 1982.
- [6] Babayan VK. Medium chain length fatty acid esters and their medical and nutritional application. *Journal of the American Oil Chemists Society*, Volume 59: 49-51, 1981.
- [7] Walstra P, Geurts TJ, Noomen A, Jellema A, van Bockel MAJS. *Principles of milk properties and processes*. Marcel Dekker, New York. Dairy Technology: 325-362 e 517-537, 1999.
- [8] Park Y.W., Juárez M., Ramos M., Haenlein G.F.W. Physico-chemical characteristics of goat and sheep milk. *Small Ruminant Research*, 68: 88-113, 2007.
- [9] Jandal J.M. Comparative aspects of goat and sheep milk. *Small Ruminant Research*, 22:177-185, 1996.

- [10] Grandison A. Causes of variation in milk composition and their effects on coagulation and cheese making. Dairy Industries International, Volume 51: 21-24, 1986.
- [11] AOAC. In K. Helrich (Ed.), Official methods of analysis (15th ed.). Arlington, VA: Association of Official Analytical Chemists, 1990.
- [12] Bradley Jr R L, Arnold Jr E, Barbano D M, Semerad R G, Smith D E and Vines B K Chemical and physical methods. In: Marshall, T.R. Standard methods for the microbiological Examination of Dairy products, 16th edition., American Public Health Association, Washington D.C., USA, 1992.
- [13] ISO 9874. Determination of total phosphorus content - Method using molecular absorption spectrometry, 2006.
- [14] ISO 8070. Milk and milk products -- Determination of calcium, sodium, potassium and magnesium contents -- Atomic absorption spectrometric method, 2007.
- [15] de Man, J.D.; Rogosa, M.; Sharpe, M.E. "A Medium for the Cultivation of Lactobacilli". J Appl Bact 23:130-135, 1960.
- [16] StatSoft. STATISTICA for Windows [Computer program manual]. StatSoft, Inc., 1998.
- [17] Tamine A.Y., Robinson R.K. YOGUR: Ciencia y Tecnologia. Zaragoza (Spain), Editorial ACRIBIA S.A.: 7-78; 235-250; 255-289;317-326, 1991.
- [18] Stelios K., Emmanuel A. Characteristics of set type yoghurt made from caprine or ovine milk and mixtures of the two. International Journal of Food and Technology, 39: 319-324, 2004.
- [19] Tamine A.Y., Wszolek M., Božanić R., Özer B. Popular ovine and caprine fermented milks. Small Ruminant Research, 101: 2-16, 2011.
- [20] NP 694, Iogurte: definição, classificação, características e acondicionamento, 1981.
- [21] Early R.. Tecnologia de los Productos Lácteos (2nd ed.). Zaragoza (Spain), Editorial ACRIBIA S.A.: 51-79; 127-147, 1998.