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Nitrogen fractions of Andalusian goat milk compared to similar types of commercial milk

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ABSTRACT

In this paper, part of a wider study on goat milk in Andalusia, the total nitrogen and the main protein fractions in commercial brands of Andalusian semi-skimmed cow milk and goat milk were measured and compared to the results for raw goat milk from the farms of a major Andalusian goat milk cooperative.

Mean total protein content was significantly higher in the untreated raw goat milk (3.67 g/100 g) than in the commercial goat milk (3.27 g/100 g) or cow milk (3.14 g/100 g). Mean non-casein content was 0.138 g/100 g in raw goat milk and 0.118 g/100 g in commercial cow milk, and mean non-protein nitrogen was significantly higher in raw goat milk (0.040 g/100 g) than in commercial cow milk (0.027 g/100 g) Nitrogen from casein peptides and from globulin was also determined.

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1. Introduction

Goat milk is a typical Mediterranean product traditionally consumed directly or as handmade cheese (Chandan, Attaie, & Sahani, 1992). It is a source of proteins of excellent quality, thanks to the proportion of essential amino acids they provide (Luquet, 1991). Goat milk is also highly digestible and the biological value of its proteins is superior to that of cow milk proteins (López-Aliaga et al., 2003; Ramos Morales et al., 2005). Its nutritional properties and lower allergenicity in comparison to cow milk, especially in non-sensitised children (Haenlein, 2004; Park & Haenlein, 2006), has led to an increased interest in goat milk as a functional food, and it now forms a part of the current trend to healthy eating in developed countries (Bevilacqua et al., 2001; Lara Villoslada, 2005).

The amount of protein in milk (which varies between different species of mammals) is critical to its commercial, technological and biological value. Thus, the greater the quantity of proteins in the raw milk, the higher is its performance in the technological transformation required to prepare derivatives, such as fermented milks or cheeses (Fontecha Alonso, Baro Rodríguez, & Boza Puerta, 2004). In recent years, increasing attention has been paid to the measurement of specific protein fractions in milk, obtained by digestion of the protein. These protein fractions, in addition to their nutritional value, regulate physiological processes and can be considered as active ingredients with a beneficial effect on general health (Baro, Jiménez, Martínez-Pérez, & Boza, 2001).

Two nitrogenous groups can be distinguished in milk, nitrogen protein and non-protein nitrogen (NPN), which represent around 95% and 5%, respectively, of total nitrogenous compounds in milk. In turn, 80% of milk proteins are caseins (complex of phosphorized proteins), which are characterised by their precipitation when the milk is acidified to a pH of 4.6 (Baro Rodríguez, López-Huertas León, & Boza Puerta, 2005). The proteins that remain in a 4.6 pH solution are called milk serum proteins or soluble proteins, largely composed of albumens and globulins, which precipitate in the presence of 12% trichloroacetic acid. Milk serum proteins are of enormous interest to the Food Industry and are used in the manufacture of numerous different food products, including newborn and follow-on infant formulas. Proteose-peptones, glycoprotein substances with an intermediate molecular weight between proteins and peptides, are N-terminal fragments that derive from α-casein hydrolysis (Walstra, Geurts, Normen, Jellema, & Van Boekel, 1999).

In this study, the main nitrogenous fractions were compared amongst raw goat milk, commercial (processed) goat milk, and commercial cow milk in order to gather specific and reliable data on their composition. These data will be invaluable to complete food composition tables and evaluate possible protein losses in technological and sterilization processes.

2. Materials and methods

2.1. Samples

Ten brands of commercial milk (5 of goat milk and 5 of cow milk) were purchased from local shops. This milk was

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semi-skimmed (1.5–1.8% fat content) and heat sterilized (UHT), which is the only commercially available type of goat milk and is a widely consumed type of cow milk. Raw goat milk was also obtained over a period of eight months from a major Andalusian goat milk cooperative, using standard sampling techniques. All samples were analysed in triplicate.

2.2. Treatment of samples

Before their analysis, samples were heated to 20° C ± 2° C and carefully mixed. The raw goat milk samples (not homogenized), were slowly heated to 40 °C, gently mixed and then cooled to 20° ± 2° C.

2.3. Determination of total nitrogen compounds in milk

Kjeldahl method (Barbano, Lynch, & Fleming, 1991; CEE 608/92, 1992).

Basic method: Milk was digested in H_2SO_4, using $CuSO_4 \cdot 5H_20$–K_2SO_4 as catalyst.
Apparatus: Kjeldahl digester flasks (Bloc digest 12 Selecta). Distillation flasks (B-316 Büchi flasks).
Digestion method: The sample was progressively heated (initially very gradually) to 400 °C and maintained at this temperature for at least 90 min until the solution achieves a transparent greenish blue colour (total digestion time should not be <150 min).
Blind assay: A blind assay using the same methodology was conducted using five millilitres of water instead of milk.
Nitrogen loss: Percentage recovery of >99% was obtained using 0.12 g of ammonium sulphate and 0.85 g of sucrose per flask.
Digestion efficiency: Percentage recovery of >98% was obtained using 0.15 g ammonium sulphate or 0.20 g tryptophan.
Precision: One sample was run ten times to test the repeatability (Table 1).

2.4. Procedure for evaluation of different protein fractions, Kjeldahl method

1. Total nitrogen. The nitrogen content of the milk, expressed as a percentage of mass, was determined by the Kjeldahl method as described above.
2. Non-casein nitrogen (NCN) (Lynch, Barbano David, Fleming, & Richard, 1998). NCN was determined by precipitation and filtration (acetic/acetate) of the casein at a pH of 4.6, applying the Kjeldahl method to the filtrate.
3. Non protein nitrogen (NPN) (Barbano, Lynch, & Fleming, 1991). NPN was determined by precipitation of the protein using 12% trichloroacetic acid, applying the Kjeldahl method to the filtrate.
4. Proteose-peptone protein + non-protein nitrogen (PPN + NPN) (Casado Cimiano, 2001). PPN and NPN were measured by precipitating the globulin and albumen in the serum obtained from the NCN (paragraph 2), applying the Kjeldahl method to the filtrate.
5. Globulin nitrogen (GN) (Casado Cimiano, 2001). GN was measured by treating the NCN with magnesium sulphate and applying the Kjeldahl method to the precipitate.
6. Nitrogen protein-3.
7. Serum protein: 2–3.

Calculations: multiply % nitrogen by 6.38 to calculate % total protein and multiply globulin by 6.40 for the casein content.

2.5. Statistical analysis

Analysis of variance was used to establish significant differences amongst samples as a function of their origin (cow/goat). The Statgraphics Plus Statistical 4.1 package (Statgraphics Plus & Statistical Graphics Corp., 1999) was used for the analyses.

3. Discussion and results

Amongst the commercial milks, the nitrogen fraction was higher in goat versus cow milk. Table 2 shows the levels and percentages of the different nitrogen fractions in the commercial milks and raw goat's milk.

The protein composition of goat milk varies amongst breeds (Marti, 1997). Studies of raw milk (no heat treatment) in Spain have reported total protein values of 3.46–3.70 g/100 g (Quiles Sotillo, 1994), 3.11–3.91 g/100 g for Granada (Andalusia) breeds, 3.49-3.73 g/100 g for Granada-Murcia breeds, 3.58 g/100 g for *Verata* goat milk (Gonzalez-Crespo, Lozano, & Serrano, 1996) and 3.52–3.99% for goats from Extremadura (Gonzalez Crespo & Roa Ojalvo, 2001). Peláez Puerto, Fresno Baquero, Díaz Romero, and Darías Martín (2004), using an automatic measurement method (Milkoscan), reported protein values of 3.85–3.96% in goat milk from the island of Tenerife in a study that considered the seasonal variability, with values reaching more than 4% in some cases during the summer. In the present study, the mean total protein value was 3.67 g/100 g, with values ranging from 3.36–4.16%.

Some authors have reported a very similar total protein composition between cow and goat milk. Thus, both types of milk were found to have a protein value of 3.3 g/100 ml by Spreer (1991) and by Walstra et al. (1999) and a value of 3.22 g/100 g by Luquet (1991). In contrast, Ordóñez Pereda et al. (1998) described significantly lower values in cow milk than goat milk (3.1–3.9 g/100 g vs. 4.2 g/100 g).

In the present study, appreciably higher total protein values were obtained in commercial (3.27 g/100 g) and raw (3.67 g/10 g) goat milk than in commercial cow milk (3.14 g/100 g), and it should be taken into account that the commercial milks were semi-skimmed (higher relative protein concentration).

Spanish food composition tables published by CESNID (2004), Mataix Verdú (2003) and Moreiras, Carbajal, Cabrera, and Cuadrado (2007) give a single value of 3.4% for total protein in whole goat milk, without differentiating between raw and heat processed milk. This is a lower value than observed in any of the

Table 1
Repeatability of the analytical method.

Component (g/100 g)	Raw goat milk				Commercial cow milk			
	n	Mean	σ_{n-1}	r (repeatability)	n	Mean	σ_{n-1}	r (repeatability)
Total nitrogen	10	0.5549	8.10×10^{-3}	0.0047	10	0.5356	9.97×10^{-3}	0.0058
Non-casein nitrogen	10	0.0848	6.25×10^{-3}	0.0036	10	0.0747	3.97×10^{-3}	0.0023
Non-protein nitrogen	10	0.0397	8.15×10^{-3}	0.0047	10	0.0397	9.68×10^{-3}	0.0056
Proteose-peptone protein + non-protein nitrogen)	10	0.0502	9.35×10^{-3}	0.0054	10	0.0400	9.70×10^{-3}	0.0056
Globulin nitrogen	10	0.0200	9.90×10^{-3}	0.0057	10	0.0100	10.02×10^{-3}	0.0058