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# The effect of heat treatment of caprine milk on the composition of cheese whey

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ABSTRACT

In three independent trials, caprine milk from the same batch was divided into three lots, which were heated at 65 °C for 30 min, 80 °C for 5 min or 90 °C for 5 min. Representative whey samples collected during the whole cheese making process were analysed for fat, protein and dry matter contents, which decreased as the heating temperature of milk increased. Percentages of serum albumin and β-lactoglobulin in the total proteins of whey decreased as the heating temperature of milk increased, while α-lactalbumin and glycomacropeptide increased, particularly in the 90 °C whey. Lactoferrin and the immunoglobulin-heavy chain were only detected in the 65 °C whey.



## 1. Introduction

A large amount of information is available on bovine whey and its products. In contrast, literature is rather sparse when it comes to caprine whey. Currently, whey processors rarely accept caprine whey, because of concerns related to flavour and seasonal volume fluctuations, and, more generally, because of lack of knowledge about the compositional and functional properties of caprine whey. As a result, small cheese manufacturers have turned to land spreading as the primary way of disposal, but this method carries both environmental and economic costs that lower financial returns (Casper, Wendorff, & Thomas, 1998).

Although less explored than bovine whey, the caprine counterpart is gaining importance due to the worldwide increase in the production of dairy products based on caprine milk (Morand-Fehr et al., 2004). Unlike in the case of bovine milk, it is possible to produce cheese by rennet coagulation from overheated caprine milk without mixing it with unheated milk (Caponio, Pasqualone, & Tommaso, 2001; Faccia et al., 2012). This offers the possibility of changing the composition of caprine sweet whey by only varying thermal processing of caprine milk.

The aim of this study was to examine the effect of different heat treatments of caprine milk on gross composition and the protein composition of cheese whey, to evaluate its potential use in food-grade products.

## 2. Material and methods

### 2.1. Cheese manufacture

Raw caprine milk was collected from a single commercial flock of 250 Saanen goats. Three batches of 60 L were obtained during the months of June and July. Each batch of milk was divided into three 20 L lots. On the same day three cheese making fabrications were done, each one (20 L) with milk subjected to different thermal treatment: T1 (65 °C for 30 min), T2 (80 °C for 5 min), and T3 (90 °C for 5 min). This fabrication scheme was repeated on three consecutive weeks. Heat treatments of milk were performed in a stainless steel cheese vat (Pro-Mont, Sremski Karlovci, Serbia). After the heat treatment, milk was cooled in the same vat, poured into a stainless steel 20 L milk cans (Migros, Kragujevac, Serbia) and kept overnight in a refrigerator at 6 °C. Rennet coagulated soft cheese was made from each lot of milk following the same cheese making process. Milk was heated in a cheese vat to 31 °C, mesophilic starter culture MWO 030 (Clerici-Sacco Group, Cadorago, Italy) was added in the amount of 0.005% (w/v), and milk was allowed to ripen for ~30 min. Then 0.02% of $CaCl_2$ was added and coagulation was done at 31 °C by calf rennet Caglificio Clerici (Clerici-Sacco Group, Cadorago, Italy). The amount of rennet was 0.2 g per 10 L of milk. After 45 min, the curd was cut to 5 cm cubes, allowed to rest for

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15 min and carefully transferred to the rectangular mold. During curd draining (10 min) and pressing (2 h), whey was collected. The entire amount of whey was thoroughly mixed and representative 300 mL whey samples (W1, W2 and W3) were taken.

### 2.2. Compositional analysis of raw milk, and whey

The composition of raw milk and whey was analysed using the following methods: total solids by a standard drying method at 102 ± 2 °C (FIL-IDF, 1987); fat content according to the Gerber method (FIL-IDF, 1981); total nitrogen content was analysed using the Kjeldahl method (FIL-IDF, 1993) and the factor of ×6.38 was used to calculate total protein content. The pH value was measured using a digital pH-meter (Consort, Turnhout, Belgium). Each analysis was done in triplicate.

### 2.3. Sodium dodecyl sulphate polyacrylamide gel electrophoresis analysis of raw milk and whey samples

The raw milk and the whey samples were mixed in mass-ratio 1:9 and 1:1, respectively, with sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE) sample buffer, pH 6.8, comprising 0.055 M Tris–HCl, 2% (w/v) SDS, 7% (v/v) glycerol, 5% (v/v) β-mercaptoethanol, and 0.0025% (w/v) bromophenol blue. Samples were applied to the gel in equal volumes of 5 μL.

SDS PAGE was performed according to the method of Laemmli (1970), as described in detail by Miloradovic, Kljajevic, Jovanovic, Vucic, and Macej (2015), using 20.5 × 10 cm TV200YK twin-plate electrophoresis unit (Consort, Turnhout, Belgium) together with Electrophoresis Power Supply EV202 (Consort). The gels were scanned using HP Scanjet G2710 (Hewlett Packard, California, USA).

The densitometric analysis of scanned gels was done using LabImage 1D L340 software (Kapelan Bio-Imaging GmbH, Leipzig, Germany).

### 2.4. Statistical analysis

The effect of heat treatments on the whey composition was analysed using Statistica 10.0 software (Stat Soft. Inc., Tulsa, USA), using general linear model (GLM) analysis of variance (ANOVA). Mean comparisons of the parameters were performed by t-test, with the level of significance at 0.05.

## 3. Results and discussion

### 3.1. Composition of raw milk and whey

The gross composition of raw caprine milk used in this experiment is presented in Table 1. In comparison with the data from literature (Park, Juárez, Ramos, & Haenlein, 2007; Raynal-Ljutovac, Lagriffoul, Paccard, Guillet, & Chilliard, 2008), the caprine milk used in this study appears to be very poor in terms of total protein and fat content.

The gross composition of the various whey samples is presented in Table 1. The analysis of variance showed that heat treatment of milk has a significant effect on chemical composition of cheese whey: when the temperature of heat treatment increased, the total protein, fat and total solids contents all decreased significantly ($P < 0.05$).

### 3.2. Protein composition of raw milk and whey

The SDS-PAGE electroforetogram of raw milk and wheys is presented in Fig. 1. The major whey proteins, β-lactoglobulin (β-lg) and α-lactalbumin (α-la), were detected in the W1 whey, along with high molecular mass whey proteins lactoferrin (LF), serum albumin (SA) and immunoglobulin-heavy chain (Ig-HC). In the same volume of whey W2 and whey W3 applied on the gel (5 μL), LF and Ig-HC were not detected by densitometric analysis. In W3, the band corresponding to SA was not detected. The percentage of β-lg decreased from 44.1% in W2 to 7.1% in W3, while the percentage of α-la increased from 27.6% in W2 to 45.6% in W3 (Table 2); therefore α-la was shown to be the caprine whey protein with the highest heat stability. According to subsequent exclusion of protein bands, along with the increase of heating temperature, the sequence of caprine whey protein heat sensitivity appears to be the same as the sequence of bovine whey protein heat sensitivity: Ig > LF > SA > β-lg > α-la, which is in accordance with what has been reported previously (Patel, 2007).

Furthermore, the 20 kDa band was present in all whey samples. According to the literature, this band corresponds to oligomers of

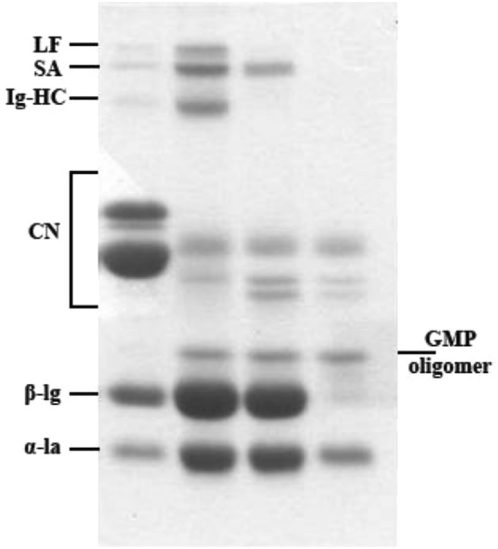


**Fig. 1.** SDS-PAGE electrophoretogram of raw milk (RM) and whey samples obtained from milk heated at 65 °C for 30 min (W1), 80 °C for 5 min (W2) and 90 °C for 5 min (W3). Abbreviations are: LF, lactoferrin; SA, serum albumin; Ig-HC, immunoglobulin heavy chain; CN, caseins; β-lg, β-lactoglobulin; α-la, α-lactalbumin; GMP, glycomacropeptide.

**Table 1**
Gross composition of raw caprine milk (RM), and whey samples obtained from cheese milk heated at 65 °C for 30 min (W1), 80 °C for 5 min (W2) and 90 °C for 5 min (W3).[a]

| Gross composition parameters | RM | W1 | W2 | W3 |
|---|---|---|---|---|
| pH | 6.63 ± 0.04[a] | 6.38 ± 0.03[b] | 6.42 ± 0.05[b] | 6.35 ± 0.04[b] |
| Total protein (%) | 2.57 ± 0.10[a] | 0.92 ± 0.14[b] | 0.72 ± 0.08[c] | 0.50 ± 0.02[d] |
| Fat (%) | 2.75 ± 0.15[a] | 1.05 ± 0.10[b] | 0.58 ± 0.17[c] | 0.35 ± 0.05[d] |
| Total solids (%) | 10.30 ± 0.04[a] | 6.78 ± 0.17[b] | 6.16 ± 0.26[c] | 5.78 ± 0.15[d] |

[a]Values are means of three replicated trials ± standard deviation; values sharing the same superscript letter are not statistically different from one another ($P > 0.05$).