ARTICLE IN PRESS

Small Ruminant Research xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

The influence of milk heat treatment on composition, texture, colour and sensory characteristics of cows' and goats' Quark-type cheeses

Zorana Miloradovic*, Jelena Miocinovic, Nemanja Kljajevic, Igor Tomasevic, Predrag Pudja

Department of Animal Source Food Technology, University of Belgrade – Faculty of Agriculture, Nemanjina 6, 11080 Belgrade, Serbia

ARTICLE INFO

Keywords:
Fresh cheese
Goat
Heat treatment
Composition
Texture
Colour

ABSTRACT

In this study, four Quark-type cheeses were produced: cows' milk cheeses made from milk subjected to 80 °C/5 min and 90 °C/5 min treatment (Cc8 and Cc9, respectively), and its analogue goats' milk cheeses (Gc8 and Gc9). Their yield and quality was evaluated one day after the production. The yields of goats' cheeses were significantly lower compared to cows' cheeses. Although the total protein content did not differ significantly between cows' and goats' cheeses, relative protein proportions were different. Heat treatment had a significant influence on major whey protein ratios, for cheeses of both milk types. The Cc9 sample had lower firmness and work of shear compared to the Cc8 sample, but there was no influence of heat treatment on the texture of goats' cheeses. All cheeses received satisfactory scores during sensory evaluation. Significantly higher L* values and Wi (Hunter) indexes were measured for Gc8 and Gc9 compared to Cc8 and Cc9.

1. Introduction

Traditionally, some form of fresh cheese is produced and consumed in nearly all countries and cultures; *Cottage Cheese*, *Quark/Tvorog* and *Fromage Frais* are among the most well known. They are all produced from cows' milk (Schulz-Collins and Senge, 2004) and their technologies and manufacture have been thoroughly reviewed (Guinee et al., 1993). On the other hand, only few fresh goats' cheeses are mentioned in literature. *Paneer* and *Channa,* for example, are of Indian provenance, but now they are consumed throughout the world (Ribeiro and Ribeiro, 2010). There is also goats' *'pasta type Quark'* cheese from Uruguay, which was recently characterized by Gámbaro et al. (2017).

In Serbia, especially in the north part of the country, a Quark-type fresh cows' cheese is widely produced. Locally, it is called *Sremski Sir*. The salted variant is used either for direct consumption, or as an ingredient for bakery products; unsalted - it is used as a cake ingredient. However, fresh goats' cheeses are produced in very low quantities, mainly in rural households, and traded in local open markets.

Recently, there has been a steady increase in fresh cheese production all over the world, mainly due to the development of the ingredient sector (Schulz-Collins and Senge, 2004). Also, dairy markets have been showing greater interest in goats' milk cheeses - in Serbia, for example (Miloradovic et al., 2015), and internationally (Sosnowski et al., 2016), and they are becoming one of the most attractive niches in the dairy industry. It is surprising therefore that, to the best of our knowledge and apart from the already mentioned reference (Gámbaro et al., 2017), there is no mention in the scientific literature of fresh Quark-type goats' cheeses.

The aim of this study is to provide practical information about the yield and the quality of both cows' and goats' Quark-type cheeses, and to give an insight into the differences that can exist between cows' and goats' cheeses even when produced by an identical process. The effect of heat treatment (80 °C/5 min and 90 °C/5 min) on the yield and quality of rennet coagulated goats' cheeses has already been investigated (Miloradovic et al., 2017). We have now applied the same heating regimes to cheese milk in order to study their impact on the yield and quality of acid-rennet coagulated cheeses.

2. Material and methods

2.1. Pre-manufacture heat treatments of goats' and cows' milk

Goats' milk used in this experiment (3.45 ± 0.07% fat, 2.65 ± 0.05% proteins, 11.24 ± 0.03% dry matter) was taken from a flock of Saanen goats, and cows' milk (3.55 ± 0.35% fat, 3.14 ± 0.21% proteins and 12.36 ± 0.50% dry matter) from a flock of Holstein-Friesian cows. Both flocks are commercial, consisted of 250–300 animals. In cows' flock, calving took place during entire year, while kidding in goats' flock beguine in February and ended up in the middle of March. For the purpose of the experiment, both milk types

* Corresponding author.
E-mail address: zorana@agrif.bg.ac.rs (Z. Miloradovic).

https://doi.org/10.1016/j.smallrumres.2018.09.012
Received 24 May 2017; Received in revised form 14 September 2018; Accepted 17 September 2018
0921-4488/

Please cite this article as: Miloradovic, Z., Small Ruminant Research, https://doi.org/10.1016/j.smallrumres.2018.09.012

were taken in May, in two consecutive weeks, for two cheese-making trials.

For each trial, 10 L of milk (both cows' and goats') was portioned into two 5 L lots. Each lot was subjected to two different heating regimes: 80 °C/5 min (Cc8/Gc8 – for manufacture of cows'/goats' cheese) and 90 °C/5 min (Cc9/Gc9 - for manufacture of cows'/goats' cheese). Heating was performed in double wall pots Gracia (Metalac, Gornji Milanovac) on an electric stove, with constant manual steering. Temperature increase rate was 4 °C/min. Prior to the addition of starter cultures, milk was cooled to room temperature (23 °C) in an ice bath, within 5 min.

2.2. Cheese manufacture and yield measurement

All four cheese variants were made according to the identical procedure: mesophylic aromatic starter culture Flora Danica (Chr. Hansens, Little Island, Cork, Ireland), consisting of (*LL*) *Lactococcus lactis* subsp. *lactis*, (*LLC*) *Lactococcus lactis* subsp. *cremoris, (LLD) Lactococcus lactis* subsp. *lactis* biovar. *diacetylactis* and (*LMC*) *Leuconostoc mesenteroides* subsp. *cremoris* was added to each lot (Cc8, Cc9, Gc8 and Gc9) in the amount of 0.002% (w/v). At the same time, calf rennet Caglificio Clerici (Clerici-Sacco Group, Cadorago, Italy) was added in the amount of 0.02 g per 10 L of milk. Milk was then subjected to combined acid-rennet coagulation during 20 h at 22–24 °C. After 20 h, cheese gel was carefully transferred to a rectangular mould with cotton cloth and pressed for 5 h by approximately 2 kg of weight per kg of cheese. The curd was then weighed for yield calculations. *Cheese yield* (CY) was calculated as the weight percentage of cheese in cheese milk used for its production (Miloradovic et al., 2017). After weighing, the cheese gels were transferred from moulds to plastic containers and stored at 4 °C for one day. Then, composition, texture, sensory quality and colour were determined in the way described below.

2.3. Syneresis of cheese gels

Syneresis was measured by the modified method of Riener et al., (2010). After the coagulation process had finished, while transferring cheese gel from vat to the moulds, 30 g of cheese gel was taken from the vat, spread evenly on a funnel covered with Whatman No. 1 filter paper placed on a graduated cylinder, and held at 4 °C for 5 h. Syneresis was expressed as volume of drained whey (ml) collected in the cylinder, per 100 g of cheese gel. The analysis was performed in duplicate.

2.4. Water-holding capacity of cheese gels

Water-holding capacity (WHC) was measured by the method of Riener et al. (2010), adapted for cheese acid-rennet gels. Briefly, two samples (25 *g*) of inoculated and renneted milk were taken from each cheese lot in centrifuge tubes, weighed out and then incubated together with the rest of cheese milk. After 20 h of acid-rennet coagulation, tubes with cheese gels were centrifuged (3000 *g*/10 min). The WHC was expressed as weight of separated whey (g) per 100 g of cheese gel.

2.5. Composition of cheeses and wheys

Total solids (TS) content of cheese and whey was determined by the standard drying method at 102 ± 2 °C (FIL-IDF, 1987); *fat* (F) content of whey - according to Gerber method (FIL-IDF, 1981); fat content of cheese - by Van Gulik method (FIL-IDF, 1986); *total nitrogen content of both whey and cheese* was analyzed by Kjeldahl method (FIL-IDF, 1993), and *total protein* (TP) content was calculated by multiplying it with 6.38. The pH value of cheeses was measured by immersing a digital pH-meter (Consort, Turnhout, Belgium) into the cheese slurry, according to (Ardö and Polychroniadou, 1999). All analysis, for all cheese-making trials, was done in duplicate.

Moisture in non-fat substance (MNFS) and *fat in dry matter* (FDM) were calculated for all cheese variants.

2.6. Protein composition of cheeses

Protein composition of cheese samples was determined by sodium dodecyl sulphate polyacrylamide gel electrophoresis (SDS-PAGE). Samples were prepared according to the method described by Miloradovic et al., (2017). The SDS-PAGE protocol and the equipment used in the experiment were described in detail by Miloradovic et al., (2015). Gels were scanned with a HP ScanJet 300 scanner (Hewlett Packard, California, USA). Bends were identified with *Protein Test Mixture 4* for SDS-PAGE analysis (Serva, Tulsa, USA) which contain phosphorylase B (97.4 kDa), bovine albumin (BSA) (67 kDa), egg albumin (45 kDa) and carbonic anhydrase (29 kDa). Scans of the SDS-PAGE electrophoretograms were used to quantify bands using densitometric software *ImageJ* (National Institute of Health, Bethesda MD, USA). SDS-PAGE analysis was performed for each cheese making trial.

2.7. Textural parameters of cheeses

Textural parameters of cheeses were measured with TA.XT Plus Texture Analyzer (Stable Micro System, Surrey, UK), using the *Spreadability Rig Probe* (HDP/SR) from the same manufacturer and a compression cell of 5 kg. Prior to testing, the lower cone holders were filled with cheese samples using a spatula, surface was leveled, samples were covered with cellophane wrap and put in the refrigerator to equilibrate to 4 °C. During the analysis, samples were extracted from the lower cone holder using a corresponding upper cone, protruding 15 mm into the sample, with a speed of 3 mm/s. Force (g) was measured, and the following parameters were calculated: *firmness* (g), *work of shear* (g x s), *stickiness* (g) and *work of adhesion* (g x s). Five samples were tested for each cheese variant and it was repeated for two cheese making trials.

Parameters used in the experiment were selected by the *Exponent* software (Stable Micro System, Surrey, UK). The *Exponent* was also used to calculate cheese texture parameters from the force vs. time curves.

2.8. Sensory quality of cheeses

Sensory evaluation of cheeses was carried out according to the method of Koca and Metin (2004), by a sensory panel consisting of eight members, all experienced in dairy product quality judging. The following four sensory characteristics were selected for evaluation: appearance, odour, oral texture and flavour. They were scored from minimum (0) to maximum (5), divided by 0.5. The evaluation of cheeses was conducted immediately after the samples were taken out from the refrigerator. Samples were presented to the panelists in a random order, labeled with 3 digit codes.

The panelists were asked to describe the sensory characteristics of cheeses.

2.9. Colour evaluation

The colour of cheeses was evaluated using a computer vision system, by the method of Girolami et al. (2013), modified by Djekic et al. (2017). Ten colour measurements were taken for each sample in all trials.

The total colour difference (ΔE*) was calculated using the following formula:

$$\Delta E^* = \sqrt{(L_c^* - L_o^*)^2 + (a_c^* - a_o^*)^2 + (b_c^* - b_o^*)^2}$$

where subscripts (c) and (o) denote cheeses that were compared, either produced from differently heated milk or made from different milk types.

The W*hiteness Index* (Wi(Hunter)) and the *Yellowness Index* (Yi(FC))

Table 1
Syneresis and water holding capacity (mean ± stdev) of acid cheese gels, obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples[1]	Syneresis (ml/100 g gel)	Water holding capacity (g/100 g gel)
Cg8	14.62 ± 0.53[a]	11.52 ± 1.59[ab]
Cg9	14.25 ± 1.06[a]	10.01 ± 1.42[a]
Gg8	18.62 ± 0.53[b]	14.08 ± 1.38[b]
Gg9	17.35 ± 0.53[b]	9.71 ± 0.45[a]

[a,b]Different letter in superscript indicate significant difference between samples (P < 0.05).
[1] Cc8 - cows' cheese gel from milk heated to 80 °C/5 min; Cc9 - cows' cheese gel from milk heated to 90 °C/5 min.
Gg8 - goats' cheese gel from milk heated to 80 °C/5 min; Gc9 - goats' cheese gel from milk heated to 90 °C/5 min.

were calculated using the following formulae (Hirschler, 2012):

$$Wi(Hunter) = L^{*} - 3 \times b^{*}$$

$$Yi(FC) = 142.86 \times b^{*}/L^{*}$$

2.10. Statistical analysis

As previously mentioned, all cheeses (Cc8, Cc9, Gc8 and Gc9,) were manufactured twice. The t*wo-way ANOVA* was used to determine the effect of factors (heat treatment and milk type) on the measured parameters. Differences between means were determined with the Duncan – test, and were considered significant if P < 0.05. The *Statistica 10.0* software (Stat Sof. Inc., Tulsa, USA) was used for all the analysis.

3. Results

3.1. Syneresis and water holding capacity of acid-gels

The results for syneresis and WHC, for both cows' and goats' acid gels, are given in Table 1. The type of milk significantly influenced the degree of syneresis (P < 0.05), and goats' milk gel showed higher capability of syneresis. The WHC, an indicator of the amount of whey that can be removed during cheese pressing (Lucey, 2004), did not differ between the gels of different milk types. However, protein matrices of both milk types heated to 90 °C/5 min had a higher capability of holding the whey, and the difference was significant (P < 0.05) in case of goats' milk gel.

3.2. Composition of cheeses and whey

In the Serbian Regulations (2014), *Fresh Cheeses* are required to have the TS content higher than 20%. This is in line with the content proposed for Quark cheese (~82%, w/w) (Schulz-Collins and Senge, 2004). Table 2 shows that the requirement has been fulfilled for all cheese variants in our experiments.

The type of milk significantly influenced the TS content (P < 0.05), and the content was higher for goats' cheeses. Contrary to what is stated in literature (see Section 3.1), this study shows that, in case of acid-rennet coagulated cheeses, the final TS content is affected by syneresis, rather than by the WHC. Therefore, higher degree of syneresis (together with lower protein content of raw milk) certainly contributes to a significantly lower yield achieved for goats' cheeses than for cows' cheeses (P < 0.05)

3.3. Protein composition of cheeses

Proteins identified by the SDS-PAGE are presented in Fig. 1. Besides casein fractions (α_s, β and *para*-κ-casein) and a notable amount of major whey proteins, high molecular weight serum proteins (*lactoferine* – LF, *serum albumin* – SA and *heavy chain of Immunoglobulin* – Ig-HC) were also detected on the gel.

Relative protein proportions were obtained by densitometric quantification of the SDS-PAGE gels. It could be seen from Table 3, that they differed significantly between cheeses from different milk type. The most pronounced difference was found in relative proportion of β-casein. Cows' cheeses contained almost half of the goats' cheese β-casein proportion (20.35 ± 6.81 and 23.71 ± 0.76 vs. 43.24 ± 3.27 and 39.89 ± 0.83, respectively).

Heat treatment had a significant influence on major whey protein ratios (Table 3) and, for cheeses of both milk types, higher levels of major whey proteins corresponded to higher heat treatments (P < 0.05). Cows' cheeses contained relative proportions of 15.12 ± 0.59 vs. 19.07 ± 0.50 of β-lactoglobulin and 7.81 ± 0.19 vs. 9.51 ± 0.65 of α-lactalbumine, respectively. Goat cheeses contained relative proportions of 8.20 ± 0.23 vs. 11.71 ± 0.60 of β-lactoglobulin and 13.22 ± 0.15 vs. 18.08 ± 0.34 of α-lactalbumine, respectively.

3.4. Texture parameters of cheeses

The firmness of cheese is primarily related to its TS content (Jack and Paterson, 1992; Buffa et al., 2001). In this study however, it appeared that the difference in TS between cows' and goats' cheeses was not sufficient to make a significant impact on their firmness (P < 0.05) (Table 4).

The difference in heat treatments of milk affected the texture of cows' cheeses (Cc8 and Cc9). Cheese sample Cc9 showed significantly lower firmness, stickiness and work of shear than the Cc8 sample. However, there was no significant difference (P < 0.05) between Gc8 and Gc9 regarding the texture attributes examined in this study.

3.5. Sensory quality of cheeses

Panelists rated all the cheese samples with either *very good* or *excellent* scores (Table 5) and found no significant difference between cheeses in any of the evaluated characteristics (P < 0.05). Cheeses were described as mild in flavour, smooth and creamy, with buttery odour, milky-white in colour; there was a slight but pleasant hint of goaty flavour in Gc8 and Gc9 samples.

3.6. Colour

It could be seen from Table 6 that there is a significant influence of milk type on the colour of cheeses (P < 0.05). Regardless of the heat treatment applied to cheese milk, goats' cheeses exhibited higher L* and Wi(Hunter) values, but lower b* and Yi(FC) values. Consequently, the total colour difference (ΔE*) was more pronounced between the cheeses of different milk types (1.3) than between the cows' (0.0) or goats' (0.1) cheeses produced from differently heated milk.

4. Discussion

4.1. Syneresis and water holding capacity of acid-gels

The amount of whey drainage from coagulated product is determined by the degree of protein denaturation and concomitant covalent aggregation of caseins and whey proteins (Chandan and O'Rell, 2006). It was discovered earlier (Miloradovic et al., 2015) that, for both cows' and goats' milk, a significant aggregation of proteins occurs after the 90 °C/5 min treatment, while, after the 80 °C/5 min treatment, only non-covalent bonds get formed. In our study, the effect of protein aggregation on the WHC was more pronounced in case of acid-rennet gels of goats' milk.

Table 2
Chemical composition (mean ± stdev) of Quark-type cheeses and its wheys Yield and pH values (mean ± stdev) of cheeses, obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples[1]	MF(%)[2]	TP(%)[2]	DM(%)[2]	MNFS(%)[2]	FDM(%)[2]	pH	Yield (%)
Cw8	0.55 ± 0.07[a]	0.62 ± 0.00	6.91 ± 0.18[a]	93.60 ± 0.25[a]	7.97 ± 1.23[a]		
Cw9	0.55 ± 0.07[a]	0.51 ± 0.09	6.61 ± 0.13[a]	93.90 ± 0.03[ab]	8.31 ± 1.02[a]		
Gw8	0.25 ± 0.07[b]	0.67 ± 0.13	6.14 ± 0.08[b]	94.09 ± 0.15[b]	4.08 ± 1.21[b]		
Gw9	0.20 ± 0.00[b]	0.57 ± 0.12	6.09 ± 0.02[b]	94.09 ± 0.02[b]	3.28 ± 0.01[b]		
Cc8	13.50 ± 1.41	9.90 ± 1.31	26.94 ± 0.16[ab]	84.47 ± 1.57	50.11 ± 5.55	4.18 ± 0.03[a]	27.35 ± 2.90[ab]
Cc9	12.25 ± 2.47	9.53 ± 0.04	25.28 ± 2.31[a]	85.14 ± 0.23	48.20 ± 5.38	4.17 ± 0.04[a]	31.25 ± 1.20[b]
Gc8	15.37 ± 0.17	10.63 ± 0.71	29.43 ± 0.45[b]	83.39 ± 0.36	52.24 ± 0.20	4.15 ± 0.03[a]	19.55 ± 0.9[c]
Gc9	14.87 ± 0.53	10.11 ± 0.30	28.30 ± 0.89[ab]	84.23 ± 0.52	52.25 ± 0.22	4.01 ± 0.00[b]	20.75 ± 4.3[ca]

[a,b,c]Different letter in superscript indicate significant difference between samples ($P < 0.05$).
Lack of superscripts indicates no significant differences ($P > 0.05$).
[1]Cw8 - cows' whey from milk heated to 80 °C/5 min; Cw9 - cows' whey from milk heated to 90 °C/5 min.
Gw8 – goats' whey from milk heated to 80 °C/5 min; Gw9 - goats' whey from milk heated to 90 °C/5 min.
Cc8 - cows' cheese from milk heated to 80 °C/5 min; Cc9 - cows' cheese from milk heated to 90 °C/5 min.
Gc8 - goats' cheese from milk heated to 80 °C/5 min;Gc9 - goats' cheese from milk heated to 90 °C/5 min.
[2]MF- milk fat; TP – total proteins; DM – dry matter; MNFS – moisture in non-fat substance. FDM – fat in dry matter;

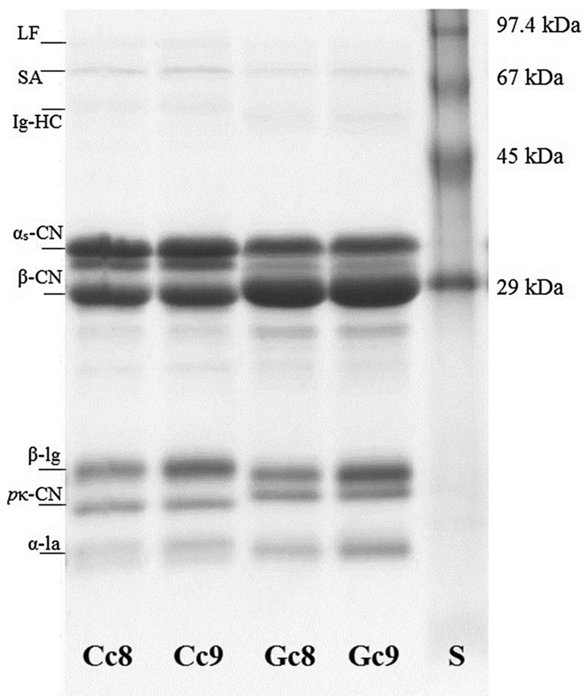

Fig. 1. SDS-PAGE electrophoretogram of Quark-type cheeses, produced from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min; Cc8 - cows' cheese from milk heated to 80 °C/5 min; Cc9 - cows' cheese from milk heated to 90 °C/5 min;Gc8 - goats' cheese from milk heated to 80 °C/5 min;Gc9 - goats' cheese from milk heated to 90 °C/5 min; S - Protein test mixture 4 for SDS-PAGE.

4.2. Composition of cheeses and whey

It was reported recently (Miloradovic et al., 2017) that the yield of soft, rennet coagulated cheeses differs significantly when milk is previously heated to 80 °C/5 min or to 90°/5 min. However, this study shows (Table 2) that, in case of acid-rennet Quark-type cheeses, such a difference does not exist ($P > 0.05$).

Similarly, while a significant difference exists in the composition (TP, F and TS content) of goats' sweet whey obtained from milk heated to 80 °C/5 min and to 90°/5 min (Miloradovic et al., 2016), there is no such difference in the case of its acid whey counterpart (Table 2). In general, whey composition depends on many factors, and it includes changes in milk processing parameters (Casper et al., 1999). However, this study showed that the applied change in heat treatment of cheese milk had no significant influence on composition of either cows' or goats' acid whey obtained from Quark-type cheese.

4.3. Protein composition of cheeses

The appearance of *para*-κ-casein and a complete absence of κ-casein (Fig. 1) indicate that, even with a low amount of rennet added, a complete hydrolysis of this casein fraction occurred during the coagulation process.

Although the type of milk did not affect the total protein content, it made a significant impact on protein composition. Significant differences in relative protein proportions between cows' and goats' milk are likely to affect both the functional properties and the biological value of cheeses - all to be a part of future research.

Furthermore, by containing predominantly β-casein - the most hydrophobic of all casein fractions (Fox and Brodkorb, 2008), protein matrix of goats' cheeses displaces whey from its mass more readily than cows' cheese matrix, resulting in a higher degree of syneresis, and

Table 3
Relative protein proportions (mean ± stdev) in Quark-type cheeses, obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples[1]	α_s-casein (%)	β-casein (%)	β-lactoglobulin (%)	α-lactalbumine (%)
Cc8	35.79 ± 0.62[a]	20.35 ± 6.81[a]	15.12 ± 0.59[a]	7.81 ± 0.19[a]
Cc9	34.35 ± 0.54 [a]	23.71 ± 0.76[a]	19.07 ± 0.50[b]	9.51 ± 0.65[b]
Gc8	20.46 ± 3.25[b]	43.24 ± 3.27[b]	8.20 ± 0.23[c]	13.22 ± 0.15[c]
Gc9	17.65 ± 0.12[b]	39.89 ± 0.83[b]	11.71 ± 0.60[d]	18.08 ± 0.34[d]

[a,b,c,d]Different letter in superscript indicate significant difference between samples ($P < 0.05$).
[1]Cc8 - cows' cheese from milk heated to 80 °C/5 min.
Cc9 - cows' cheese from milk heated to 90 °C/5 min.
Gc8 - goats' cheese from milk heated to 80 °C/5 min.
Gc9 - goats' cheese from milk heated to 90 °C/5 min.

Table 4
Textural parameters (mean ± stdev) of Quark-type cheeses, obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples[1]	Firmness (g)	Work of Shear (g x s)	Stickiness (g)	Work of Adhesion (g x s)
Cc8	1679.6 ± 317.4[a]	1671.2 ± 400.8[a]	1653.6 ± 239.1[a]	387.0 ± 93.5
Cc9	1383.1 ± 54.8[b]	1272.4 ± 36.5[b]	1421.1 ± 20.9[b]	315.8 ± 27.8
Gc8	1604.2 ± 106.8[ab]	1397.7 ± 91.0[b]	1673.1 ± 135.7[a]	370.4 ± 41.4
Gc9	1552.6 ± 105.1[ab]	1450.7 ± 88.3[ab]	1568.2 ± 115.2[ab]	371.8 ± 28.2

[a,b,c]Different letter in superscript indicate significant difference between samples (P < 0.05).
Lack of superscripts indicates no significant differences (P > 0.05).
[1] Cc8 - cows' cheese from milk heated to 80 °C/5 min; Cc9 - cows' cheese from milk heated to 90 °C/5 min.
Gc8 - goats' cheese from milk heated to 80 °C/5 min; Gc9 - goats' cheese from milk heated to 90 °C/5 min.

Table 5
Sensorial parameters (mean ± stdev) of Quark-type cheeses, obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples[1]	Appearance	Odour	Oral texture	Flavour
Cc8	4.81 ± 0.37	4.66 ± 0.52	4.22 ± 0.56	4.72 ± 0.36
Cc9	4.81 ± 0.37	4.75 ± 0.37	4.19 ± 0.81	4.78 ± 0.34
Gc8	4.97 ± 0.09	4.91 ± 0.19	4.16 ± 0.30	4.59 ± 0.32
Gc9	5.00 ± 0.00	4.75 ± 0.46	4.35 ± 0.55	4.94 ± 0.11

Lack of superscripts indicates no significant differences (P > 0.05).
[1]Cc8 - cows' cheese from milk heated to 80 °C/5 min.
Cc9 - cows' cheese from milk heated to 90 °C/5 min.
Gc8 - goats' cheese from milk heated to 80 °C/5 min.
Gc9 - goats' cheese from milk heated to 90 °C/5 min.

consequently in higher TS content.

4.4. Texture parameters of cheeses

In general, whey protein incorporation caused by high heat treatment leads to a weaker casein matrix (Rynne et al., 2004). It has been reported that increased preheating of cows' milk (90 °C/15 min) causes a decrease of firmness in GDL acidified gels. The effect was explained by a higher level of denatured whey protein/casein bindings, resulting in a finer branched protein network (Guinee et al., 1993).

According to previous findings (Miloradovic et al., 2015), when goats' milk is heated to 80 °C/5 min, only the non-covalent bonding occurs between proteins, while after the 90 °C/5 min treatment, these are mostly disulphide bridges that connect whey proteins with casein. However in the findings of Vasbinder et al. (2003) and Nguyen et al. (2015) it was stated that a higher amount of thiol groups in preheated milk results in higher gel hardness and greater resistance to large deformation.

There are two hypotheses that could make a connection between the mentioned claims from literature and the data from this study.

The first hypotheses assumes that, if the exposed thiol groups formed during heat treatment are present in the milk after cooling, the thiol-disulphide exchange continues to occur during acid gelation. If that is so, the similarity in Gc8 and Gc9 firmness could be attributed to the additional disulfide cross-links formed from the exposed thiol groups in the milk heated to 80 °C/5 min.

The second hypothesis suggests that heat-induced serum aggregates can bind to the casein micelles during acid gelation via electrostatic (Donato et al., 2007) or hydrophobic interactions (Outinen, 2010), resulting in an increase of cheese hardness. This hypothesis would mean that the exposition of thiol groups in milk heated to 80 °C/5 min had never happened and that the non-covalent bonds were responsible for the similarity of cheese textures of Gc8 and Gc9.

More detailed research would be required to confirm either of those hypotheses. Regardless of which hypothesis is finally confirmed, it is right to assume that whey proteins in 80 °C/5 min heated goats' milk are gel-forming proteins.

4.5. Sensory quality of cheeses

According to literature, certain deficiencies in oral texture could occur in fresh cheeses if the degree of protein denaturation is insufficient (too soft texture) or excessive, with the occurrence of protein aggregation (sandy texture) (Schulz-Collins and Senge, 2004). However, even with a significant difference in protein aggregation after the two applied heating regimes (as mentioned before), neither sandiness nor too soft oral texture was reported.

Satisfactory sensory quality of Gc8 and Gc9 confirmed that the cheese-making procedure commonly used for Quark-type cows' cheese (*Sremski Sir*) could be successfully adapted for its goats' analogue.

4.6. Colour

According to Schulz-Collins and Senge (2004), the colour of Quark cheese is 'milky white to faintly yellowish'. Because of their smaller fat globules and a complete conversion of β-carotene into vitamine A, goats' cheeses are generally whiter than cows' cheeses (Park, 2006). With the instrumental technique used in this study, it was possible to distinguish between the colours of Quark type goats' cheese and cows' cheese, even only a day after they were produced. This could be helpful, since substitution of higher valued goats' milk by cows' milk is a common way of adulteration in cheese-making practice (Mafra et al., 2007).

Table 6
Colour parameters (mean ± stdev) of Quark-type cheeses obtained from cows' and goats' milk heated to 80 °C/5 min and 90 °C/5 min.

Samples	L*	a*	b*	Wi(Hunter)	Yi(FC)	Samples	ΔE*
Cc8[1]	92.0 ± 0.0[a]	0.0 ± 0.0	1.0 ± 0.0[a]	89.0 ± 0.0[a]	1.5 ± 0.0[a]	Cc8:Cc9	0.0
Cc9	92.0 ± 0.0[a]	0.0 ± 0.0	1.0 ± 0.0[a]	89.0 ± 0.0[a]	1.5 ± 0.0[a]	Gc8:Gc9	0.1
Gc8	91.1 ± 0.1[b]	0.0 ± 0.0	0.0 ± 0.0[b]	91.1 ± 0.1[b]	0.0 ± 0.0[b]	Cc8:Gc8	1.3
Gc9	91.1 ± 0.1[b]	0.0 ± 0.0	0.1 ± 0.1[b]	90.8 ± 0.3[b]	0.1 ± 0.2[b]	Cc9:Gc9	1.3

[a,b]Different letter in superscript indicate significant difference between samples (P < 0.05).
Lack of superscripts indicates no significant differences (P > 0.05).
[1]Cc8 - cows' cheese from milk heated to 80 °C/5 min; Cc9 - cows' cheese from milk heated to 90 °C/5 min.
Gc8 - goats' cheese from milk heated to 80 °C/5 min; Gc9 - goats' cheese from milk heated to 90 °C/5 min.

5. Conclusion

The results of this study confirm that both cows' and goats' fresh Quark-type cheeses of excellent sensory quality can be produced by the same cheese-making process. Consequently, the procedure traditionally used in Serbia for the manufacture of '*Sremski Sir*' cows' cheese, could be successfully adopted for production of goats' cheeses of similar type, albeit with somewhat different characteristics.

Although the total protein contents did not differ between cheeses of two milk types, the relative protein proportions of casein fractions and whey proteins, determined by the SDS-PAGE, were significantly different. All this suggests that the functional characteristics and the biological values of goats' and cows' cheeses of this type are likely to be different, but this needs to be investigated further.

Contrary to what was determined earlier for rennet coagulated brined cheeses, for fresh acid-rennet cheeses from milk of different heating regimes there was no difference in either yield or in composition of whey. In similarity with rennet coagulated cheeses, heat treatment did cause higher whey protein incorporation in Cc9 and Gc9 compared to Cc8 and Gc8, respectively. The Cc9 sample had lower firmness and work of shear compared to the Cc8 sample. However, heat treatment had no influence on the texture of goats' cheese. Again, more research is needed in that area to find out the cause of such a different behavior.

We believe that fast and high definition colour assessment technique, used in this study, could be developed into a method for detection of goats' cheese adulteration with economically lower valued cows' milk.

The results of this study could serve as a basis for standardization of fresh cows' cheese '*Sremski Sir*', as well as for the development of a new variety of fresh goats' cheese.

Conflict of interest

There is no conflict of interest to declare.

Acknowledgment

This work was supported by the the Ministry of Education, Science and Technological Development of Republic of Serbia (Grant III 46009)

References

Ardö, Y., Polychroniadou, A., 1999. Laboratory Manual for Chemical Analysis of Cheese. Office for Official Publications of the European Communities, Luxembourg.
Buffa, M.N.N., Trujillo, A.J., Pavia, M., Guamis, B., 2001. Changes in textural, microstructural, and colour characteristics during ripening of cheeses made from raw, pasteurized or high-pressure-treated goats' milk. Int. Dairy J. 11, 927–934.
Casper, J.L., Wendorff, W.L., Thomas, D.L., 1999. Functional properties of whey protein concentrates from caprine and ovine specialty cheese wheys. J. Dairy Sci. 82, 265–271.
Chandan, R.C., O'Rell, K.R., 2006. Manufacture of various types of yogurt. In: Chandan, R.C. (Ed.), Manufacturing Yogurt and Fermented Milks. Blackwell Publishing, USA, pp. 210–236.
Djekic, I., Vunduk, J., Tomašević, I., Kozarski, M., Petrovic, P., Niksic, M., Pudja, P., Klaus, A., 2017. Application of quality function deployment on shelf-life analysis of Agaricus bisporus Portobello. Lwt – Food Sci. Technol. 78, 82–89.
Donato, L., Alexander, M., Dalgleish, D.G., 2007. Acid gelation in heated and unheated milks: interactions between serum protein complexes and the surfaces of casein micelles. J. Agric. Food Chem. 55, 4160–4168.
FIL-IDF, 1981. Determination of Fat Content. Gerber Butyrometers. Milk. International Dairy Federation, Brussels, Belgium.
FIL-IDF, 1986. Determination of Fat Content. Cheese and Processed Cheese Products. International Dairy Federation, Brusseles, Belgium.
FIL-IDF, 1987. Determination of Total Solids Content. Milk, Cream and Evaporated Milk. International Dairy Federation, Brussels, Belgium.
FIL-IDF, 1993. Milk-determination of Nitrogen Content (Kjeldahl Method). International Dairy Federation, Brussels, Belgium, pp. 1–12.
Fox, P.F., Brodkorb, A., 2008. The casein micelle: historical aspects, current concepts and significance. Int. Dairy J. 18, 677–684.
Gámbaro, A., González, V., Jiménez, S., Arechavaleta, A., Irigaray, B., Callejas, N., Grompone, M., Vieitez, I., 2017. Chemical and sensory profiles of commercial goat cheeses. Int. Dairy J. 69, 1–8.
Girolami, A., Napolitano, F., Faraone, D., Braghieri, A., 2013. Measurement of meat color using a computer vision system. Meat Sci. 93, 111–118.
Guinee, T.P., Pudja, P., Farkye, N.Y., 1993. Fresh acid-curd cheese varieties. In: Fox, P.F. (Ed.), Cheese: Chemistry, Physics and Microbiology, Springer Science + Business Media. Dordrecht, The Netherlands, pp. 363–421.
Hirschler, R., 2012. Whiteness, yellowness, and browning in food colorimetry. In: Caivano, J.L., Buera, Md.P. (Eds.), Color in Food. Technological and Psychophysical Aspects. CRC Press Taylor & Francis Group, Boca Raton, London, New York, pp. 90–102.
Jack, F.R., Paterson, A., 1992. Texture of hard cheeses. Trends Food Sci. Technol. 3, 160–164.
Koca, N., Metin, M., 2004. Textural, melting and sensory properties of low-fat fresh kashar cheeses produced by using fat replacers. Int. Dairy J. 14, 365–373.
Lucey, J.A., 2004. Formation, structural properties and rheology of acid-coagulated milk gels. In: Fox, P.F., Mc Sweeney, P.L.H., Cogan, T.M., Guinee, T.P. (Eds.), Cheese Chemistry, Physics and Microbiology. Elsevier Ltd., London, UK, pp. 104–122.
Mafra, I., Roxo, Á., Ferreira, I.M.P.L.V.O., Oliveira, M.B.P.P., 2007. A duplex polymerase chain reaction for the quantitative detection of cows' milk in goats' milk cheese. Int. Dairy J. 17, 1132–1138.
Miloradovic, Z., Kljajevic, N., Jovanovic, S., Vucic, T., Macej, O., 2015. The effect of heat treatment and skimming on precipitate formation in caprine and bovine milks. J. Dairy Res. 82, 22–28.
Miloradovic, Z., Macej, O., Kljajevic, N., Jovanovic, S., Vucic, T., Zdravkovic, I., 2016. The effect of heat treatment of caprine milk on the composition of cheese whey. Int. Dairy J. 58, 39–42.
Miloradovic, Z., Kljajevic, N., Miocinovic, J., Tomic, N., Smiljanic, J., Macej, O., 2017. High heat treatment of goat cheese milk. The effect on yield, composition, proteolysis, texture and sensory quality of cheese during ripening. Int. Dairy J. 68, 1–8.
Nguyen, N.H.A., Anema, S.G., Guyomarc'h, F., Wong, M., Havea, P., 2015. The effect of the addition of thiol reagents to heated milk on protein interactions and acid gelation properties. Int. Dairy J. 42, 42–50.
Outinen, M., 2010. Effect of Pre-treatment of Cheese Milk on the Composition and Characteristics of Whey and Whey Products. Aalto University Espoo, Finland.
Park, Y.W., 2006. Goat milk – chemistry and nutrition. In: Park, Y.W., Haenlein, G.F.W. (Eds.), Handbook of Milk of Non-Bovine Mammals. Blackwell Publishing, Iowa, USA, pp. 34–59.
Ribeiro, A.C., Ribeiro, S.D.A., 2010. Specialty products made from goat milk. Small Rumin. Res. 89, 225–233.
Riener, J., Noci, F., Cronin, D.A., Morgan, D.J., Lyng, J.G., 2010. A comparison of selected quality characteristics of yoghurts prepared from thermosonicated and conventionally heated milks. Food Chem. 119, 1108–1113.
Rynne, N.M., Beresford, T.P., Kelly, A.L., Guinee, T.P., 2004. Effect of milk pasteurization temperature and in situ whey protein denaturation on the composition, texture and heat-induced functionality of half-fat Cheddar cheese. Int. Dairy J. 14, 989–1001.
Schulz-Collins, D., Senge, B., 2004. Acid- and acid/rennet-curd cheeses. Part a: quark, cream cheese and related varieties. In: Fox, P.F., McSweeney, P.L.H., Cogan, T.M., Guinee, T.P. (Eds.), Major Cheese Groups: Cheese - Chemistry, Physics and Microbiology. Elsevier Academic Press, Amsterdam, The Netherlands, pp. 301–328.
Serbian Regulation, 2014. Amendment on Serbian Regulation 2010' Quality of Dairy Products and Starter Cultures', 33/10. Official Bulettin of the Republic of Serbia, Belgrade, Serbia.
Sosnowski, M., Rola, J.G., Osek, J., 2016. Alkaline phosphatase activity and microbiological quality of heat-treated goat milk and cheeses. Small Rumin. Res. 136, 132–136.
Vasbinder, A.J., Alting, A.C., Visschers, R.W., de Kruif, C.G., 2003. Texture of acid milk gels: formation of disulfide cross-links during acidification. Int. Dairy J. 13, 29–38.