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**QUALITY CHARACTERISTICS OF WHITE BRINED CHEESE  
PRODUCED FROM GOAT MILK WITH DIFFERENT SOMATIC CELL  
COUNT**

TATYANA BALABANOVA, MIHAELA IVANOVA \*

*University of Food Technologies, 26 Maritsa Blvd., 4002 Plovdiv, Bulgaria*

\*corresponding author: mivanova@uft-plovdiv.bg

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**Abstract**

This experimental work aimed to investigate the quality characteristics of white brined cheese during ripening, produced from goat milk with different somatic cell count: I group – with low somatic cell content (CL) with about 1 200 000 cells/ml; II group – with high somatic cell content (CH) with about 1 750 000 cells/ml and III group – with medium somatic cell content (CM) with about 1 600 000 cell/ml (CM). Chemical, microbiological, and sensorial evaluations were performed on the 1<sup>st</sup> and 45<sup>th</sup> day of cheese ripening. The obtained results showed that the differences in the composition of goat milk during the different stages of lactation as well as the level of somatic cell count had a significant effect ( $p < 0.05$ ) on the chemical composition of the cheese samples. It was established that the total lactic acid bacteria count in the experimental samples decreased from 8.2 to 7.9 log cfu/g for CL and CM and to 7.5 log cfu/g for CH at the end of the ripening period respectively. It was found that the psychrotrophic microorganisms and total yeast and molds decreased during the ripening period. The sensorial evaluation demonstrated a higher score for CL and CM samples in comparison with the CH sample.

**Keywords:** quality, ripening, somatic cell count, white brined cheese

**Introduction**

The dairy industry is the most important agricultural sector in Bulgaria. For the dairy industry, the white brined cheese is a main national dairy product with old and long traditions. After cow milk, sheep and goat milk are the basic raw materials used in the production of high-quality dairy products (Da Silva and Da Costa, 2019). The quality of raw milk is determined by its chemical composition and its sanitary and hygienic characteristics (Sharma *et al.*, 2011; Petzer *et al.*,

2017). The chemical composition of milk determines its nutritional value, technological properties, and cheese yield. The sanitary and hygienic condition of milk is determined by two main characteristics: total bacterial count (TBC) and somatic cell count (SCC). The high content of the total bacterial count in milk (over 100 000 cfu/ml for cows and over 1 500 000 cfu/ml for sheep and goats), according to Regulation (EC) No 853/2004, poses a potential risk to the health of consumers and deteriorates the technological qualities of milk. The presence of a high somatic cell count in milk is an indicator of inflammation of the mammary gland (mastitis). According to a number of authors, the indicator somatic cell count (SCC) is widely used to assess the quality and suitability of milk (Sharma *et al.*, 2011; Hunt *et al.* 2013).

Goat milk has many essential components, especially proteins with high biological quality, nutritional and functional properties and is a good source of vitamins, minerals like calcium, phosphorus, riboflavin, and medium-chain fatty acids (Bergillos-Meca *et al.*, 2015; Clark and García, 2017; Verruck *et al.*, 2019). Goat milk with different SCC load was explored in order to determine its influence on product quality (Balabanova and Ivanova, 2021). Further research about white brined cheese quality according to the somatic cell count of the used goat milk has to be made.

Therefore, the aim of the present work was to investigate the quality characteristics of white brined cheese, produced from goat milk with different levels of somatic cell count.

### Materials and methods

Goat milk was delivered at different times of the year (May, August, and November) from Plovdiv 1 Farm, Orizare village, Plovdiv region, Bulgaria and met the requirements of Regulation 853/2004. The analysis of the chemical composition of the milk (milk fat, milk protein, solids and lactose, as well as dry matter (water content, respectively), solid-non-fat, freezing point, density, proteins, lactose, minerals), titratable and active acidity, absence of antibiotics, as well as its microbiological characteristics (total bacterial count – TBC - and somatic cell count - SCC), were already published (Balabanova and Ivanova, 2021) (Table 1).

On the basis of somatic cell count values, goat milk samples were categorized into three groups: CL - white brined cheese produced from goat milk containing about 1 200 000 cell/ml SCC; CM - white brined cheese produced from III group goat milk containing 1 600 000 cell/ml SCC; CH - white brined cheese produced from II group goat milk containing about 1 750 000 cell/ml SCC.

White brined cheese, from the three groups, was produced applying a classic production technology (Edgaryan and Panayotov, 2011). The milk was clarified (at 35 to 45°C), pasteurized (at 68 to 70°C for 10–15 min), cooled (at 32 to 34°C) and inoculated with a starter culture containing *Lactobacillus delbrueckii* ssp. *bulgaricus*, *Streptococcus thermophilus*, *Lactobacillus casei*, *Lactococcus lactis* ssp. *lactis* in the amount of 0.15%.

**Table 1.** Chemical and microbiological composition of raw goat milk.

Properties <sup>1</sup>	Goat milk		
	May	August	November
Dry matter, %	12.75 ± 0.34 <sup>a</sup>	12.00 ± 0.25 <sup>b</sup>	12.63 ± 0.30 <sup>a</sup>
Solid non-fat, %	8.80 ± 0.10 <sup>a</sup>	8.50 ± 0.04 <sup>b</sup>	8.60 ± 0.05 <sup>a</sup>
Milk fat, %	3.95 ± 0.05 <sup>a</sup>	3.50 ± 0.06 <sup>b</sup>	3.90 ± 0.05 <sup>a</sup>
Proteins, %	3.40 ± 0.10 <sup>a</sup>	3.20 ± 0.11 <sup>a</sup>	3.30 ± 0.10 <sup>a</sup>
Lactose, %	4.60 ± 0.10 <sup>a</sup>	4.45 ± 0.04 <sup>b</sup>	4.60 ± 0.08 <sup>a</sup>
Minerals, %	0.80 ± 0.01 <sup>a</sup>	0.80 ± 0.02 <sup>a</sup>	0.80 ± 0.01 <sup>a</sup>
Density, g/cm <sup>3</sup>	1.029 ± 0.002 <sup>a</sup>	1.029 ± 0.001 <sup>a</sup>	1.028 ± 0.001 <sup>a</sup>
Freezing Point, °C	- 0.570 ± 0.001 <sup>a</sup>	-0.567 ± 0.001 <sup>b</sup>	-0.569 ± 0.001 <sup>a</sup>
Titrateable acidity, °T	18 ± 1 <sup>a</sup>	17 ± 2 <sup>a</sup>	17 ± 1 <sup>a</sup>
pH	6.78 ± 0.03 <sup>a</sup>	6.72 ± 0.03 <sup>a</sup>	6.76 ± 0.01 <sup>a</sup>
Test for detection of antibiotics and inhibitors	Negative	Negative	Negative
TBC, cfu/ml	6.8x10 <sup>5</sup> ± 250 <sup>a</sup>	9.1x10 <sup>5</sup> ± 320 <sup>b</sup>	7.4x10 <sup>5</sup> ± 300 <sup>c</sup>
SCC, cell/ml	1 200 000 ± 1440 <sup>a</sup>	1 750 000 ± 1750 <sup>b</sup>	1 600 000 ± 1600 <sup>c</sup>

a-c Means with different letters within a row are significantly different (p<0.05)

<sup>1</sup>Data based on (Balabanova and Ivanova, 2021) analysis.

A 30 mL portion of calcium dichloride solution (50%) (previously diluted in water in 1:10 ratio) per 100 L of milk and rennet (previously diluted in water in 1:10 ratio) were added in such amount that the coagulation started 7 to 9 min after the enzyme addition and the complete coagulation took place after 40 to 60 min. A coagulum set was formed and the curd was cut vertically and horizontally in cubes of 2 or 3 cm in size and left to stand for 10 to 15 min. The curd was stirred 2 or 3 times at intervals of 10 to 15 min. The polyethylene layer was separated, the curd was de-wheyed and a cheese block was formed. It was self-pressed for 10 min, shaped by untying and breaking 2 to 3 times in 10 to 15 min intervals and a final shaping and pressing took place in order to assure the height of the cheese block of 10 cm, length and width multiples of 10 cm. The first (40 kg per total cheese block) and second (80 kg per total cheese block) pressing were realized. The cheese block was further cut into smaller pieces of 120 x 120 cm when the water content of the fresh cheese achieved 62% and titrateable acidity of 50 to 80°Th. Salting in brine was carried out at the following parameters: salt in brine concentration – 20 to 22%, titrateable acidity – up to 25°Th, brine temperature – 14 to 15 °C, time for brining 14 to 16 h. During this stage, the white brined cheese achieved a 2.2% salt content. The cheese was arranged in metal boxes and further dry salted with 200 g of salt equally distributed between four layers of cheese. The preliminary cheese ripening took place at 15 to 18°C for 48 h until the titrateable acidity reached 180 to 200 °Th. A brine solution (8 to 10% salt content and titrateable acidity 150 to 180°Th) was added to the boxes which were further

hermetically closed. The cheese ripened (at 8 to 10°C and relative humidity 70–75%) for 45 days.

Cheese samples were analyzed on the 1<sup>st</sup> and 45<sup>th</sup> day of ripening for the following chemical parameters: fat content according to Gerber-Van Gulik method (BS 1671-89); Dry matter and water content according to (BS 1109-89); Sodium chloride content according to BS 8274-82; Determination of total nitrogen content by Kjeldahl method (BS EN ISO 8968-1:2001); Titratable acidity by the Thorner's method (BS 1111-80) and potentiometric pH measurement.

Cheese samples were evaluated by the following microbiological parameters - Total lactic acid bacteria count according to the IDF Standard 117B (1997); Determination and enumeration of psychrotrophic microorganisms (BS ISO 17410:2019); Total yeast and mould (BS EN ISO 6611:2006); Coliforms (ISO 4831:2006); *L. monocytogenes* (BS EN ISO 11290-1:2017); Coagulase-positive Staphylococci (BS EN ISO 6888-1:2005).

The sensorial evaluation of the cheese samples was carried out according to BNS 15612:83.

Statistical analysis was performed with computer processing of the results using the program Microsoft Excel 2010 (ANOVA). The results are presented as mean value  $\pm$  SD (n=12). The results were considered statistically different when  $p < 0.05$ .

## Results and discussion

Table 2 presents the results of the physicochemical analysis of cheese samples on the first and last day of the ripening process. The results showed that the differences in the composition of the goat milk (Table 1) during the different stages of lactation had a significant impact on the composition of the cheese and the processes activity that took place during the ripening period.

A constant decreasing tendency in the values of pH was established during the process of ripening in the samples CL, CM, and CH. A more active lactic acid process and an increase in titratable acidity were reported in CL and CM samples and less acidification for CH. The established trend was directly dependent on the buffer capacity, e.g. the oxidation reduction potential in the system and the change of some components (proteins and lactose) under the action of the lactic acid bacteria (Figure 1).

Vianna *et al.* (2008) reported that milk with higher SCC results in the increase of pH in cheese samples, while another author (Bangieva, 2019) found that pH decreases at the end of the ripening period. At the beginning of the ripening process the salt content in the cheese was  $3.2 \pm 0.1\%$  and by the end of the studied period the salt content increased to about 3.5%. The dynamics of the salting process in the experimental samples were closely dependent on the structure of the cheese and its water content.

Table 2. Chemical composition of white brined cheese during ripening.

Properties	CL		CH		CM	
	1 <sup>st</sup> day	45 <sup>th</sup> day	1 <sup>st</sup> day	45 <sup>th</sup> day	1 <sup>st</sup> day	45 <sup>th</sup> day
Water content, %	58.80 ± 0.23 <sup>aA</sup>	54.50 ± 0.24 <sup>bA</sup>	60.30 ± 0.22 <sup>aB</sup>	55.50 ± 0.24 <sup>bB</sup>	58.30 ± 0.25 <sup>aA</sup>	53.90 ± 0.25 <sup>bB</sup>
Dry matter, %	41.20 ± 0.30 <sup>aA</sup>	45.50 ± 0.24 <sup>bA</sup>	39.70 ± 0.22 <sup>aB</sup>	44.50 ± 0.24 <sup>bB</sup>	41.70 ± 0.25 <sup>aA</sup>	46.10 ± 0.23 <sup>bA</sup>
NaCl, %	3.20 ± 0.04 <sup>aA</sup>	3.50 ± 0.05 <sup>bA</sup>	3.30 ± 0.04 <sup>aB</sup>	3.50 ± 0.04 <sup>bB</sup>	3.20 ± 0.05 <sup>aC</sup>	3.50 ± 0.04 <sup>bC</sup>
Fat content, %	18.50 ± 0.10 <sup>aA</sup>	21.50 ± 0.15 <sup>bA</sup>	18.50 ± 0.10 <sup>aA</sup>	21.50 ± 0.15 <sup>bA</sup>	19.00 ± 0.15 <sup>aB</sup>	22.00 ± 0.10 <sup>bB</sup>
Fat in dry matter, %	44.90 ± 0.14 <sup>aA</sup>	47.25 ± 0.20 <sup>bA</sup>	46.60 ± 0.14 <sup>aB</sup>	48.31 ± 0.19 <sup>bB</sup>	45.56 ± 0.20 <sup>aC</sup>	47.72 ± 0.14 <sup>bC</sup>
Total protein, %	17.50 ± 0.05 <sup>aA</sup>	16.00 ± 0.06 <sup>bA</sup>	16.80 ± 0.07 <sup>aB</sup>	14.20 ± 0.10 <sup>bB</sup>	17.50 ± 0.10 <sup>aA</sup>	16.50 ± 0.05 <sup>bC</sup>
Titratable acidity, °T	178 ± 2 <sup>aA</sup>	230 ± 2 <sup>bA</sup>	170 ± 2 <sup>aB</sup>	219 ± 2 <sup>bB</sup>	180 ± 2 <sup>aA</sup>	225 ± 2 <sup>bC</sup>
pH	5.12 ± 0.02 <sup>aA</sup>	4.71 ± 0.03 <sup>bA</sup>	5.21 ± 0.02 <sup>aB</sup>	4.80 ± 0.04 <sup>bB</sup>	5.10 ± 0.03 <sup>aA</sup>	4.77 ± 0.04 <sup>bB</sup>

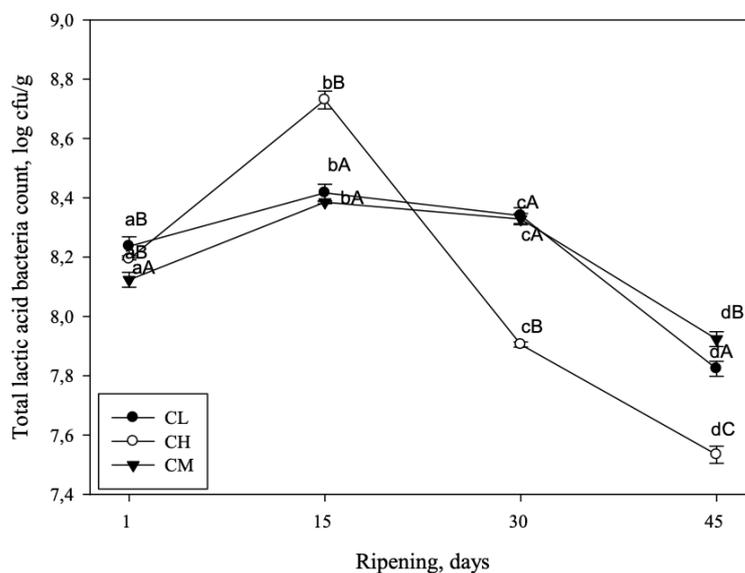
a-c Means with different letters within columns, for the same sample but for a different ripening period, are significantly different (p<0.05)

A-C Means with different letters within columns, for the same ripening period, are significantly different (p<0.05)

The active diffusion processes in these samples created a condition for relatively fast equalization of the salt content in the different layers of the cheese. While in the studies of Sulejmani and Hayaloglu (2017) that indicator in fresh cheese was in the range of 2.02 ÷ 2.73%, the observed data from Barac *et al.* (2017) for the salt content in white brined goat's milk cheese for the period 10<sup>th</sup> to 50<sup>th</sup> day of production were significantly lower – 1.85 ÷ 2.10%. This change was due to the different values of the characteristics dry matter, water content, brine concentration, and acidification, as well as the applied specific technology. It was established that the values of the dry matter indicator increased along with the gradual decrease of the water content in the cheese. The average value of that indicator was in accordance with the results obtained from Bojanić Rašović *et al.* (2010). The total protein in the system decreased during the studied period due to the proteolysis of the protein molecule. The values of the fat content in the total mass of the three cheese samples changed compared to the change in the dry matter content. Our results were consistent with the results of (Dimitrova *et al.*, 2020), which indicated that fat contents in cow cheese ranged between 21-27%.

Figure 1 shows the dynamics in the development of the total lactic acid bacteria count during ripening of the studied samples of white brined cheese from goat's milk. The results showed that at the beginning of the ripening process in the two experimental samples goat milk cheese was approximately 8.1 log units. These values indicated the good development of starter lactic acid bacteria in the previous stages of the technological process. A slightly higher total lactic acid bacteria count was found in CL which was a piece of evidence for a more intensive development during the pre-ripening period and correlated with the higher reported values for the water content indicator. In all analyzed samples there was an increase in the amount of lactic acid bacteria count during the first 15 days of ripening.

The conducted research established the clear influence of SCC on the ripening process and at the same time, the development of the lactic acid bacteria count. From the 15<sup>th</sup> to the 30<sup>th</sup> day in samples CL and CM there were insignificant changes ( $p > 0.05$ ) in the lactic acid bacteria count, which corresponded to the stationary phase of its development. A more significant reduction ( $p < 0.05$ ) in lactic acid bacteria count was established between the 15<sup>th</sup> and 30<sup>th</sup> day after the ripening of the CH samples. After that period until the end of ripening, the trend changed and a constant process of reduction of lactic acid biomass was observed and at the end of the process has reached values from 7.9 log cfu/g (CL and CM) to 7.5 log (CH). These results were similar to the results obtained at the end of the ripening period for Macedonian traditional white brined cheese (Sandra *et al.*, 2013) where the mean lactic acid bacteria content was 7.0 log cfu/g.



**Figure 1.** Change of total lactic acid bacteria count in white brined cheese from goat's milk during ripening. <sup>a-d</sup> Means with different letters within a range are significantly different ( $p < 0.05$ ); <sup>A-C</sup> Means with different letters within different series are significantly different ( $p < 0.05$ ).

The results regarding the change of the nonstarter microflora in samples of white brined goat milk cheese during the ripening process are presented in Table 3. The low levels of nonstarter microflora in the samples were a result of the good hygienic conditions in the production process, as well as the correct conduct of the technological operations.

**Table 3.** Survival of nonstarter microflora in white brined cheese from goat's milk during ripening.

Nonstarter microflora, cfu/g	CL		CH		CM	
	1 <sup>st</sup> day	45 <sup>th</sup> day	1 <sup>st</sup> day	45 <sup>th</sup> day	1 <sup>st</sup> day	45 <sup>th</sup> day
Psychrotrophic microorganisms	$1.2 \times 10^3 \pm 0.1^{aA}$	$1.3 \times 10^2 \pm 0.1^{bA}$	$1.1 \times 10^3 \pm 0.2^{aB}$	$1.2 \times 10^2 \pm 0.1^{bB}$	$1.0 \times 10^3 \pm 0.2^{aC}$	$1.1 \times 10^2 \pm 0.1^{bC}$
Yeast and mold	<100	ND	<100	ND	<100	<10
Coliforms	ND	ND	ND	ND	ND	ND
Listeria monocytogenes	ND	ND	ND	ND	ND	ND
Coagulase-positive staphylococci	ND	ND	ND	ND	ND	ND

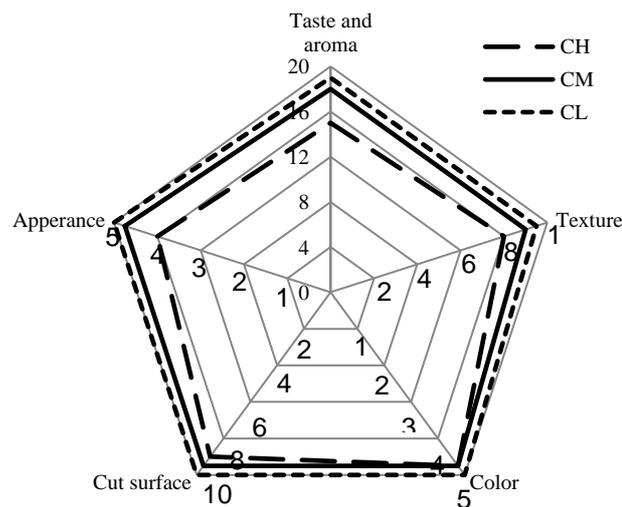
<sup>a-b</sup> Means with different letters within columns, for the same sample but for a different ripening period, are significantly different ( $p < 0.05$ ); <sup>A-C</sup> Means with different letters within columns, for the same ripening period, are significantly different ( $p < 0.05$ ); ND – not detected.

Psychrotrophic microorganisms can get into the cheese at any stage of production, from technological equipment and can contaminate the finished product. The contamination of the tested samples with psychrotrophic microorganisms at the beginning of the ripening process was low and varied between  $1.0$  and  $1.2 \times 10^3$  cfu/g. The normal development of the lactic acid bacteria count during the ripening process was accompanied by an increase in acidity and inhibited the development of the psychrotrophic microflora. The viability of yeast in white brined cheese depends on many factors - composition of milk, nutrients availability, interactions with co-existing microorganisms, production, storage conditions and etc. (Soliman Neveen and Salwa, 2011; Buehler *et al.*, 2017; Lacanin *et al.*, 2017).

It was established that the yeast and mould count decreased during the ripening period which correlated with the increase in acidity. In a contrast with our results, Šuranská *et al.* (2016) established that the total yeast counts in Serbian artisanal white-brined cheese increased during the ripening period between the 1<sup>st</sup> to 10<sup>th</sup> day (from  $10^4$  to  $10^6$  cfu/g).

According to Chipilev *et al.* (2016), which analyzed white brined cheeses from Bulgarian dairies, produced with heat treated cow milk and vacuum packaged after a ripening period of 45 days, concluded that more than 63% of cheese samples were contaminated with yeast in total counts of  $10^2$  to  $10^6$  cfu/g. The present study did not detect the presence of coliform bacteria, coagulase-positive staphylococci, and listeria monocytogenesis. Our results correspond with the results obtained from Kalevska *et al.* (2017). These results comply with the regulations on special demands for microbiological criteria for food.

The results of the sensorial evaluation of the tested samples of white brined goat milk cheese at the end of the ripening process are presented in Figure 2.



**Figure 2.** Sensorial evaluation of white brined cheese from goat milk during ripening.

The obtained data showed that the samples CL and CM had better taste-aromatic properties, specific for the respective type of cheese, whereas the samples CH were characterized by a lower sensorial evaluation. The three batches of cheese had a typical appearance - good shape of the individual pieces, correct square base, and standard sizes.

The CL and CM cheese samples were characterized by a moderately hard and elastic consistency, a smooth cut surface with a visible gloss of the fracture, without layering, and uniform white color. CH cheese samples had a slightly elastic and slightly greasy consistency. This is probably due to lower established acidity values and higher water content. According to Chen *et al.* (2010) high SCC (1 000 000 cell/ml < SCC < 1 500 000 cell/ml) in goat milk seems to affect the sensory characteristics and quality of matured cheeses.

### Conclusions

The occurrence of bacterial infection in dairy animals led to a number of adverse changes in the composition and properties of milk and the quality of the finished product. The production of white brined cheese from goat milk, containing a high somatic cell count, was characterized by altered chemical composition and sensorial profile. The conducted research established a clear influence of SCC on the dynamic of the ripening process and at the same time, faster development of the lactic acid bacteria count. Therefore, the use of milk with high values of SCC resulted in different quality characteristics of white brined cheese compared to milk with low and medium SCC.

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