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EFFECT OF SOMATIC CELL COUNTS OCCURRED IN MILK ON QUALITY OF SLOVAK TRADITIONAL CHEESE – PARENICA

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ABSTRACT

The aim of this work was to compare somatic cell count in milk used for making steamed cheese Parenica in Slovak industrial dairies and small farm dairies and to find out whether somatic cell counts in milk affect the dry matter content of Parenica cheese. The samples of raw milk were taken from 3 industrial dairies (A, B, C) and from 3 farm dairies (E, F, G), produced traditional Slovak cheese Parenica in period from January untill December 2018. The somatic cell count in milk was determined by Fossomatic^{TM} 5000 (*Foss*, Denmark) and dry matter of cheese by oven drying method to constant weight. There were no statistically significant differences (p >0.05) for somatic cell counts in milk processed in industrial and farm dairies. Lower somatic cell counts were determined in milk samples from industrial dairies (mean value 326.55 thousand in 1 mL) in comparison to milk samples from farm dairies (mean value 507.67 thousand in 1 mL). Statistically lower dry matter content (p <0.01) in the samples of Parenica cheese was found out in farm dairy E in comparison to other dairies. The relationship between somatic cell count in milk and dry matter in cheese was confirmed by the relatively low correlation coefficients in dairies, A = 0.22; C = 0.15 and F = -0.12 and higher correlation coefficients in dairies, B = -0.32; D = 0.45 and E = -0.48. Obtaining a more accurate effect of somatic cell count on cheese quality requires the continuation of the research on a larger number of samples and consideration of other factors.

Keywords: somatic cell count; cow milk, steamed cheese; industrial dairy; farm dairy

INTRODUCTION

To consistently manufacture high-quality dairy products, processors are demanding higher quality raw milk, which can be defined as (1) compositionally complete (e.g. protein and fat levels within norm); (2) free from off-flavors and odors; (3) free from detectable drug residues, added water, or other adulterants; (4) having low total bacteria counts; and (5) having low somatic cell counts **(Murphy et al., 2016)**.

Somatic cell count in milk is commonly used as an index of udder health in lactating dairy cattle **(Constable et al., 2016)**.

Taking cow milk as an example, most healthy cows in a dairy herd have a somatic cell count less than 5 x 10^4 cells.mL^{-1}. When somatic cell count exceed >2 x 10^5 cells.mL^{-1}, the udder is considered to be infected and mastitis is considered as subclinical **(Hachana, Znaidi and M´Hamdi, 2018)**. **Regulation (EC) No. 853/2004** of the European Parliament and of The Council of 29 April 2004 on the specific hygiene rules for food of animal origin, states that the raw cow´s milk should not contain more than 4 x 10^5 cells.mL^{-1} of somatic cells. The legal somatic cell count threshold for milk acceptance in dairy industries varies in different countries, e.g. the values for bovine milk in Germany, Canada, and the USA are 1 x 10^5 cells.mL^{-1}, 5 x 10^5 cells.mL^{-1} and 7.5 x 10^5 cells.mL^{-1}, respectively. For goat and ovine milk, the cutoff value for somatic cells is 1 x 10^6 cells.mL^{-1} in the USA but is not defined yet in the EU **(Li et al., 2014)**.

Somatic cells found in bovine milk are primarily lymphocytes, macrophages, and polymorphonuclear leucocytes, but they may also include a low percentage of epithelial cells from the gland. Somatic cells are known to be one of the major defense components of the mammary gland against diseases or intramammary infections **(Li et al., 2014; Murphy et al., 2016)**. Besides the immune defense role in the udder, somatic cells can continue their protective function in milk. For example, polymorphonuclears have bactericidal and respiratory burst activities and they can eliminate the invading bacteria by releasing reactive oxygen species and granular enzymes **(Paape et al., 2003)**. Some antibacterial proteins identified in bovine milk also arise from somatic cells such as macrophage scavenger receptor type I and II, polymorphonuclear peptidoglycan recognition protein and lymphocyte cytosolic protein I and cathelicidins. They can continue to exert their protective properties when they are in skim milk, whey, or milk fat globule membranes **(Hettinga et al., 2011)**. The role of the lysozyme, one of the somatic cell's endogenous enzymes is well known for its ability to destroy the bacteria **(Paape et al., 2003)**. Some proteinase from polymorphonuclears, such as cathepsin G, elastase, and proteinase 3, have antimicrobial activites during phagocytosis of invading microorganisms. Catalase, an endogenous enzyme from polymorphonuclears is antioxidant enzymes in milk and is suspected of being responsible for changed redox potential of milk that limited the survival capability of microorganisms **(Hamed, El Feki and Gargouri, 2008)**.

Whether somatic cells is "fiend or a foe" in the dairy field remain a question **(Souza et al., 2012)**. Generally, somatic cells, until now, have been considered as negative **(Li et al., 2014)**. High somatic cell count is associated with an inflammatory response of the mammary gland to pathogen microorganism infection **(Bobbo et al., 2017, Potter, Arndt and Hristov, 2018)**. The negative effect of high somatic cell count includes decrease of feed efficiency, lower milk production, modification in milk composition and economic losses **(Bobbo et al., 2017; Hachana, Znaidi and M´Hamdi, 2018; Potter, Arndt and Hristov, 2018)**. Higher milk somatic cell count is associated with lower content of casein and lactose and greater pH, compared to the normal values **(Giaccone, Scatassa and Todaro, 2005; Li et al., 2014; Bobbo et al., 2017; Hachana, Znaidi and M´Hamdi, 2018)**.

Somatic cells are considered as important sources of enzymes that damage milk components and potentially result in product defects. A large range of enzymes are released into milk after lysis of somatic cells, and among them, lipases (e.g., lipoprotein lipase), oxidases (e.g., catalase and lactoperoxidase), glycosidases (e.g., lysozyme) and proteases (e.g. cathepsins, elastase, and collagenase) **(Li et al., 2014; Murphy et al., 2016)**. The role of these enzymes in dairy product quality has not been fully investigated. Elastase possibly influences coagulation properties of milk, and cathepsin B and D may play a role in cheese ripening. With increased somatic cell count is also associated increased plasmin activity. Plasmin´s role in the breakdown of caseins is significant because they are the major milk proteins that are captured in the coagulation process (e.g. cheese making). Plasmin hydrolysis of β-casein results in γ-caseins and proteose-peptones, which are lost in the whey during manufacture of cheese **(Murphy et al., 2016)**.

The negative effect of high somatic cell counts in raw milk on dairy industry include reduced shelf life of dairy products, due to undesirable sensory attributes caused mainly lipolytic and proteolytic enzymes **(Hachana, Znaidi and M´Hamdi, 2018)**. Higher levels of proteolysis have been observed in cheeses made with high somatic cell count **(Le Maréchal et al., 2011)**. Somatic cell count results in decreased cheese yield as a consequence of the low casein content and a decrease of major albumins (i.e. α-lactalbumin and β-lactoglobulin). However, increased somatic cell count induces an increase in immunoactive proteins (lactoferrin, lysozyme), as well as bovine serum albumine. Increased somatic cell count is also associated with increased rennet coagulation time, decreased of curd firmness, increased cheese moisture, decreased moisture-adjusted cheese yield or cheese yield efficiency, and reduce cheese quality **(Giaccone, Scatassa and Todaro, 2005; Litwińczuk et al., 2011; Murphy et al., 2016)**.

The aim of the work was to compare somatic cell count in milk used for making steamed cheese Parenica in Slovak industrial dairies and small farm dairies. The aim was also to verify whether somatic cell counts in milk affect the dry matter content of Parenica cheese.

Scientific hypothesis

We assume that between milk processed in industrial dairies and milk processed directly in small farm dairies will be differences in quality. We expect that milk processed in farm dairies will have a lower somatic cell count than milk in industrial dairies. We expect that higher somatic cell count in milk will affect quality of cheese and will decrease their dry matter content.

MATERIAL AND METHODOLOGY

The samples of raw milk were taken from 3 industrial dairies (A, B, C) and from 3 farm dairies (E, F, G) produced traditional Slovak cheese Parenica in period from January ´till December 2018. The samples of milk stabilized with dichroman potassium were analyzed within 24 hours of collection by Fossomatic™ 5000 (*Foss*, Denmark).

The dry matter content was determined by oven drying method (**ISO 5534:2004)** by drying to constant weight at 102 ±2 °C.

Statistic analysis

Analyses were replicated twice and they were calculated from obtained values – mean values, standard deviation, variation coefficient and correlation coefficient.

The obtained results were processed by variation-statistical method in ANOVA of Statistica CZ9.1 software (Stat Soft Ltd., Czech Republic). The differences were considered significant at the p <0.05 level.

RESULTS AND DISCUSSION

Somatic cell counts determined in raw cow's milk samples, taken from industrial dairies (A, B, C) and small farm dairies (E, F, G) during the year 2018, are in the Table 1. There were no statistically significant differences (p >0.05) for somatic cell counts in milk processed in industrial and farm dairies.

Lower somatic cell counts were determined in milk samples from industrial dairies (mean value 326.55 thousand in 1 mL) in comparison to milk samples from farm dairies (mean value 507.67 thousand in 1 mL), that is in the agreement with our hypothesis. Industrial dairies buy milk from multiple vendors and it can be assumed that these dairies are interested in quality of purchased milk, while also motivating their suppliers who pay for milk on the basis, not onlyn of quantity, but also of milk quality. On the contrary, the quality of milk processed in farm dairies, which unlike to industrial dairies do not make regular milk analyzes, can vary greatly. It is in accordance with the value of variation coefficient (Table 1) and Figure 1 and Figure 2. The low values of mean somatic cell count and the variation coefficient were determined only for milk samples taken from farm dairy D. It is apparently related to the human factor (professional competence of farm staffs, interest in product quality).

Table 1 Somatic cell count x 1000 in 1 mL in milk samples from industrial and farm dairies.

mont	industrial dairies			farm dairies		
	A	**B**	**C**	**D**	**E**	**F**
January	268	243.5	417	140.5	24	2535
February	293.5	264.5	393	324.5	232	716.5
March	388	199.5	435	241	430	266.5
April	302	226.5	340	267	290	426
May	333.5	535.5	415	303	3288	392
June	297.5	430	443.5	587.5	712	373
September	356	134	374.5	145	243.5	277
October	270.5	244.5	399.5	320.5	189	380.5
November	264	282.5	373	476.5	260	659.5
December	280.5	261	330.5	145	227.5	357.5
mean	305.35	282.15	392.15	295.05	589.60	638.35
min	264	134	330.5	140.5	24	266.5
max	388	535.5	443.5	587.5	3288	2535
s_x	39.17	110.27	35.90	138.80	915.39	647.63
var (%)	12.83	39.08	9.16	47.04	155.26	101.45

Note: *samples were taken once per month.

Table 2 Dry matter of Parenica cheese (g.100 g^{-1}) produced in industrial and farm dairies.

month	industrial dairies			farm dairies		
	A	**B**	**C**	**D**	**E**	**F**
January	53.1	51.57	53.35	50.23	45.69	49.38
February	49.25	52.80	52.06	51.77	46.17	47.93
March	51.73	53.30	47.50	54.20	49.69	47.95
April	48.80	52.44	47.86	48.93	47.13	50.26
May	49.60	50.44	48.81	48.81	43.49	53.47
June	49.19	49.97	49.62	49.62	44.45	51.47
September	49.80	50.24	49.26	49.26	44.76	49.15
October	49.88	52.20	49.45	49.45	46.39	50.42
November	47.90	48.43	49.24	49.24	44.67	50.95
December	49.79	50.04	49.61	49.61	46.85	48.83
mean	49.91	51.14	49.68	49.68	45.93	49.98
min	47.90	48.43	47.50	47.50	43.49	47.93
max	53.10	53.30	53.35	53.35	49.69	53.47
s_x	1.41	1.47	1.68	1.68	1.67	1.62
var (%)	2.82	2.88	3.39	3.39	3.63	3.25

Note: *samples were taken once per month.

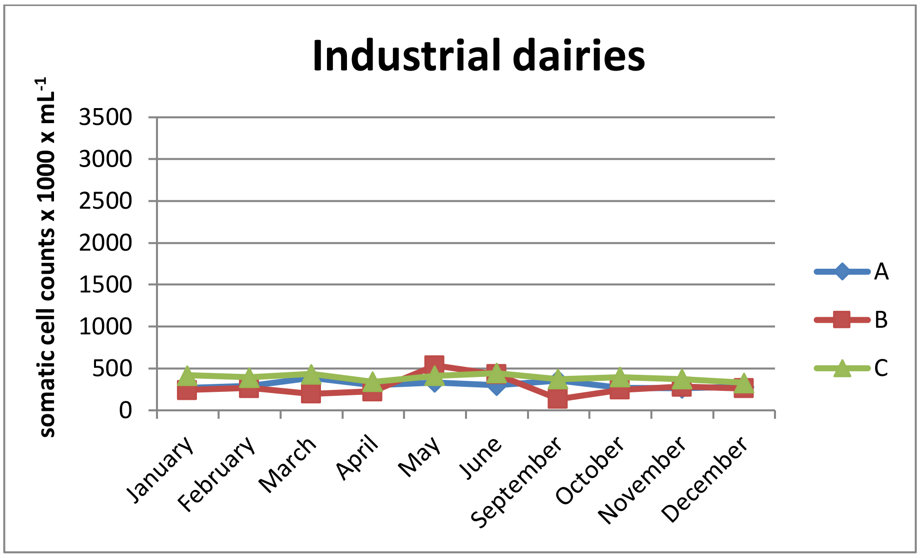

Figure 1 Somatic cell counts in samples of milk taken once per month during the year from industrial dairies (A, B, C).

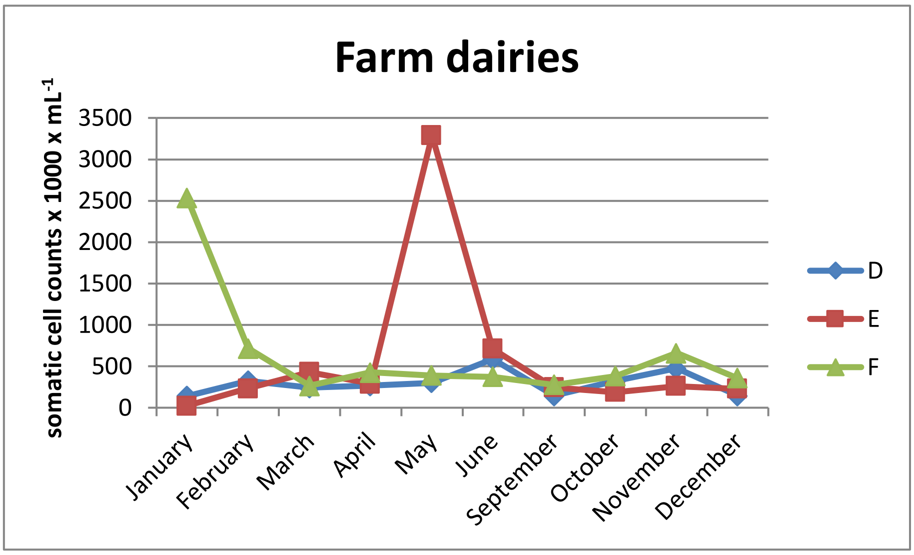

Figure 2 Somatic cell counts in samples of milk taken once per month during the year from farm dairies (D, E, F).

Kvapilík et al. (2016) determined somatic cell counts in milk from 14 experimental stables for the years 2012 – 2015 with mean value 288 thousand in 1 mL and value of variation coefficient, 3.6%. **Hristov et al. (2015)**, **Giallongo et al. (2016)** and **Giallongo et al. (2017)** reported that in cow milk samples natural logarithm of somatic cell counts x 10^3 cells in 1 mL 3.7; 4.3 and 3.2 respectively. **Litwińczuk et al. (2011)** found out that in the summer, $\log_{10}$ somatic cell count ranged from 4.68 to 6.04, whereas in the winter it ranged from 4.52 to 6.01.

Somatic cell count in milk is influenced except udder inflammation by many other factors, such as animal species, milk production level, lactation stage, individual and environmental factors, as well as management practices **(Rupp et al., 2000)**.

The somatic cell count is higher in goats and sheep milk, including milk samples from healthy udders and increases throughout the lactation period **(Šustová, Kuchtík and Kalhotka, 2016)**. **Giaccone, Scatassa and Todaro (2005)** determined in sheep's milk mean values of somatic cell count (expressed as $\log_{10}$) 6.40 and 5.56.

The dry matter content of steamed cheese Parenica from individual dairies is shown in Table 2.

Statistically lower dry matter content (p <0.01) in the samples of Parenica cheese was found in farm dairy E, in comparison to other dairies. The relationship between somatic cell count in milk and dry matter in cheese was confirmed by the relatively low correlation coefficients in dairies A = 0.22; C = 0.15 and F = -0.12, and higher correlation coefficients in dairies B = -0.32; D = 0.45 and E = -0.48.

It can be assumed that not only the somatic cell count in the processed milk, but much more factors (e.g. milk rennetability, technology of cheesemaking and others), influence the dry matter of steamed cheese.

The effect of somatic cell counts on dry matter of cheese is not unambiguous, as can be seen from the works of other authors.

For example, the authors mentioned below did not find the influence of the somatic cell count on the dry matter of the cheeses.

Cooney et al. (2000) blended milk from cows with high somatic cell count at the end of lactation with bulk tank milk with low somatic cell count. They made Swiss type cheese with three levels of somatic cell count (113,000; 228,000 and 528,000 cells in 1 mL). They observed that there was no difference in moisture of cheese, but increased protein loss in whey.

Andreatta et al. (2007) pooled milk from cows in single herd based on somatic cell count level (<200,000 and >800,000 cells in 1 mL). They reported no difference in textural parameters and moisture of produced mozzarella cheese in relationship to somatic cell count level, but increased free fatty acids nd decreased protein during storage.

Hachana, Znaidi and M´Hamdi (2018) determined the effect of low (<115,000 cells in 1 mL), medium (422,000 cells in 1 mL) and high (>987,000 cells in 1 mL) somatic cell count on mozzarella cheese quality. Their results shown that no significant differences were observed in moisture, fat, and total protein contents among mozzarella cheese samples from milk with different somatic cell count categories. However, cheese samples produced from high somatic cell count milk had significantly higher pH (6.83), compared to samples produced with low and medium somatic cell count milk (5.58 and 5.46), respectively.

The influence of somatic cell count on sheep milk composition and cheese-making properties evaluated **Giaccone, Scatassa and Todaro (2005)**. They produced cheeses from bulk milk with somatic cell count at level 6.40 and 5.56 (expressed as $\log_{10}$). They found out that somatic cells influenced very significant (p <0.05) the lactodynamographic parameters of the milk – increase for clotting time and marked decrease of curd firmness. No statistical differences were found for Tuma and Pecorino cheeses in relationship to somatic cell count in milk.

However, there are also some works in the literature, which authors have found out that a higher number of somatic cells in milk has reduced the dry matter of the cheese produced.

Auldist et al. (1996) collected milk from herds with late lactation cows and compared cheddar cheese made from milk with 252,000 and 1,400,000 somatic cells in 1 mL. The group of cheeses produced from milk with higher somatic cell count had higher moisture (+8.1%) than cheese produced from milk with lower somatic cell count. These authors also found out that the textural defects are related to high moisture, as well as flavor defects associated with lipolysis and fat oxidation.

Vianna et al. (2008) compared quality of Prato cheese produced from milk with somatic cell count lower than 200,000 cells in 1 mL and higher than 700,000 cells in 1 mL. They found out about 3% higher value of moisture in the cheese produced from milk with higher somatic cell count, and they also reported increase of rennet coagulation time about 30%.

Klei et al. (1998) evaluated cottage cheese curd made from milk collected from the same 8 cows before and after an induced *Streptococcus agalactiae* infection with mean somatic cell count of 83,000 and 872,000 cells in 1 mL, respectively. The authors found decreased yield efficiency (4.3%), higher moisture, and increased proteolysis in cottage cheese curd made with the postinfection high somatic cell count milk.

Although from some published works seems to indicate that a particularly high number of somatic cells affects cheese production and quality, including dry matter of cheese, it is difficult to accurately determine the degree to which affect it cheeses.

CONCLUSION

The somatic cell count is currently our best industry indicator for milk quality related to udder health. From the somatic cells, which are gradually lysed, different kind of enzymes and antimicrobial agents are released. Several papers show that these compounds could negatively affect both – production yield and cheese quality.

From our results, as well as the results of several authors, the influence of the somatic cell count in milk on dry matter of cheese can not be clearly confirmed.

Obtaining a more accurate effect of somatic cell count on cheese quality requires the continuation of the research on a larger number of samples and consideration of other factors e.g. content of casein and whey protein, urea, calcium in milk, milk rennetability and other factors.

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