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Influence of management and physiological factors on somatic cell count in raw cow milk in Kosova

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ABSTRACT

The main aim of this research was to study the effect of somatic cell count (SCC/mL) in raw milk in some cattle dairy farms according to the existing standards for raw milk quality in Kosovo. The results derive from 2203 individual samples from milk recording laboratory analyses in the period August 2007-February 2008. The GLM model was used to analyze the effect of different variables on the presence of SCC in raw milk. The effect of all variables was considered as a fixed. The overall results show that herd ($P<0.0001$), breed ($P<0.0004$), month of the year ($P<0.0001$) and lactation number ($P<0.0005$), respectively, had a significant effect on the presence of SCC. According to the existing legislation in regard to the quality of raw milk for 2008 and 2009 the results gained show that if the milk quality produced continues to be the same then about 78.45% for 2008 and 70.88% for 2009, respectively, will belong to extra class milk quality (SCC/mL<300.000, SCC/mL<200.000). While about 11.31% for 2008 and 16.61% for 2009 will belong to poor quality milk-below standard (SCC/mL<600.000, SCC/mL<400.000). Although the presence rate of SCC on raw milk tends to be relatively low, it cannot by any means be underestimated bearing in mind that a high rate of SCC in raw milk is negatively correlated with farmers' profit, consumer food safety and overall animal health.

Key words: fresh milk, somatic cell count, milk quality standards

Introduction

High somatic cell counts (SCC) present in milk are the main indicators of mammary gland infection, caused by specific and non specific micro-organisms, which cause contagious and environmental mastitis. Milk is an animal product of high nutritive value

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synthesized by special cells of the mammary glands, which is almost sterile when secreted from the udder alveolus. Normally, in milk from a healthy mammary gland, the SCC is lower than 100,000 cells/mL, while bacterial infection can cause it to increase to above 1,000,000 SCC/mL.

An elevated SCC in milk has a negative influence on the quality of raw milk. Subclinical mastitis is always related to low milk production, changes to milk consistency (density), reduced possibility of adequate milk processing, low protein and high risk for milk hygiene which may even contain pathogenic organisms. The largest negative consequences of the presence of SCC are related to shorter shelf time and less sensory content or un-desirable organo-leptic characteristics of the final product, due to enzymatic activities from somatic cells (TÖPEL, 2004).

The high presence of SCC in milk affects the activity of yogurt fermentation (TAMIME and ROBINSON, 1999) and can even stop this process. FERNANDES et al. (2007) studied the effect of SCC in raw milk on the chemical and physical properties of yogurt. He concluded that an increase in SCC causes an increase in fatty acids in yogurt during the preservation period and thus shortens the time of preservation of this product.

It is also known that other factors influence the presence of SCC in raw milk, that mainly have to do with different farm management, the geographical region, breeding techniques, climate and season, etc. It was found that the SCC increases with advanced parities and also in the summer season (SKRZYPEK et al., 2004; ERDEM et al., 2007).

In this aspect it is very important to study the effects of these parameters on milk quality, in order to improve and monitor the necessary milk quality (according to standards). Through these studies various suitable techniques can be explained, assessed and applied for the identification of SCC in order to assure higher raw milk quality in Kosovo.

The goal of this research was twofold: Firstly, to study the influence of breed, farm management, lactation number and month of the year (season) on SCC. Secondly, considering the legislation for milk quality, whether raw milk produced in commercial cattle dairy farms in Kosovo meets the proposed standards.

Materials and methods

Cattle management practices on commercial farms in Kosovo. Kosovo has a semi-continental climate, with average rain of 631 mm and yearly temperatures about 11 °C over the last 20 years. The animals are usually kept inside almost all year long. During this period animal feed is provided by the farmers, which usually contains hay of different plants, silage, and concentrate. Because of small surface area of land (1.57 hectare per farm) which in many cases is fragmented into many plots, cattle grazing is only organized by few Kosovo farmers. Both types of milking systems were used (open

systems, defined as using milking machines with jars, and closed systems defined as using milking machines with milk pipes). Most commercial farms have a drinking water system installed, available *ad libitum*.

Data registration, handling and sample analysis. In this study we included the 13 largest commercial cattle dairy farms all around Kosovo. Milk recorders (the project staff from the Support Project to the Kosovo Centre for Livestock Breeding (KCLB)) were responsible for milk sampling and farm data collection. The analyzes of SCC derived from raw milk samples using the standard method-A4 according to the International Committee for Animal Registration (ICAR), covering the period from September 2007 to February 2008. The daily test milk sample (evening and morning) amounted to 40-50 mL of milk which was mixed and pooled together in a sterile bottle. The samples were obtained using milk meter(s) when milking pipe system was present, whilst a calibrated syringe was used when cows were milked using milking jars. Azidol was used for sample preservation. For the two specimens (evening and morning) and for transport to the laboratory, milk samples were placed in a portable cooler at 4 ^{o}C. In general, registration cards were used for cow data recording with: identification number, breed, sample number, lactation period, farm name, birth date, calving date, amount of milk produced, and some other information relevant to this study. In some cases, incomplete or unclear data were excluded from the data. This was due to lack of experience in milk recording and farm data recording in Kosovo.

Somatic cell content was analyzed at the Ministry of Agriculture, Forestry and Rural Development (MAFRD) laboratory using "FossomaticMinor" equipment. The results gained were compared according to the Administrative Instructions MA-nr. 20/2006 used to define milk quality standards and raw milk category (Table 1).

Table 1. Raw milk quality standards in Kosovo (SCC/mL)

Year	Extra class	Class Ist	Class IInd	Class III^{d}
2007	<400.000	<500.000	<600.000	>600.000
2008	<300.000	<400.000	<500.000	<600.000
2009	<200.000	<300.000	<400.000	-

Statistical analyses. The data were analyzed using JMP- starter packet a business unit of SAS program, (SALL et al., 2004) by PROC- GLM procedure (General Linear Model). The Duncan test was used (STEEL and TORRIE, 1980) to see the effect of different variables in SCC.

Results

The number of milk samples per farm, the least square means (LSM), standard error (SE), and the standard deviations (Std DEV) for the presence of somatic cell count in raw milk are shown in Table 2.

Table 2. Influence of different farm management on somatic cell count in raw milk (SCC/mL)

Effect	Somatic cell count per farm (SCC/mil-000)		
	N	LSM ± SE	SD
Effect of farm* in SCC			
Farm I	48	98.31 ± 66.91 ^{f}	135.92
Farm II	99	124.78 ± 46.59 ^{f}	172.37
Farm III	90	174.02 ± 48.87 ^{ef}	277.19
Farm IV	135	157.97 ± 39.90 ^{f}	282.89
Farm V	442	133.09 ± 22.05 ^{f}	213.69
Farm VI	49	908.86 ± 66.23 ^{a}	1167.68
Farm VII	161	640.01 ± 36.54 ^{b}	536.92
Farm VIII	269	197.69 ± 28.27 ^{ef}	306.25
Farm IX	102	181.89 ± 45.90 ^{ef}	240.78
Farm X	139	287.25 ± 39.32 ^{de}	642.16
Farm XI	476	300.01 ± 21.25 ^{d}	616.10
Farm XII	100	412.72 ± 46.36 ^{c}	662.81
Farm XIII	93	166.17 ± 48.07 ^{ef}	254.21
Analyses of variances	Df	Pr>F	
Effect of farms	12	0.0001	

Number of samples (N); Least square means (LSM); Standard error (SE); Standard deviation (SD); Analyses of variance (Pr>F), Degree of freedom (Df).

According to the results for SCC there were large differences between the farms included in the study ($P<0.0001$). In general, based on the existing standards from 13 farms included in this study, 10 of them in 2008 and 9 in 2009 produce extra quality milk, ranging from 93.31 to 300.01 SCC/mL milk.

The lowest quality milk was produced at farm VI, followed by farms VII and XII, with SCC 908.86, 640.01 and 412.71, respectively. However, extra quality milk was produced by farms I, II, and V with SCC of only 98.31, 124.78 and 133.09 SCC/mL milk, respectively.

Table 3. Influence of different cow breed on somatic cell count in raw milk (SCC/mL)

Effects	Somatic cell count per farm (SCC/mL-in 000)		
Effect of breed in SCC	N	LSM ± SE	SD
Black Holstein	653	310.36 ± 19.04 [ab]	466.109
Brown Swiss	354	423.31 ± 25.85 [a]	701.027
Crosses	100	282.98 ± 48.64 [bc]	432.394
Montbeliard	132	285.87 ± 42.34 [b]	358.980
Red Holstein	475	190.38 ± 22.32 [c]	420.262
Simmental	489	214.60 ± 22.00 [bc]	418.770
Analyses of variance	Df	Pr>F	
Effect of breed	5	<0.0001	

Number of samples (N); Least square means (LSM); Standard error (SE); Standard deviation (STD DEV); Analyses of variance (Pr>F), Degree of freedom (Df).

The square means, standard error and the analysis of the effect of the variables of breed, lactation month and lactation in turn on SCC are shown in Tables 3, 4 and 5. For three of these variables the observed differences were clearly significant (P<0.0001).

From analyzes made in Table 3 the results show that high producing cattle breeds such as Brown Swiss (423.31) and Black Holstein (310.36), seem to be more exposed to the higher presence of SCC/mL in milk. Other breeds, like Red Holstein (190.38), Simmental (214.60), Crosses (282. 98) and Montbeliard (285.87) tend to have lower SCC counts although milk quality produced is in Class Extra and 1st Class , according to milk standards.

Cows in the first lactation and those included in fifth lactation and above seem to be less exposed to udder infections, so their SCC/mL in milk are around 178.45 and 205.61, respectively (Table 4). High SCC is shown to occur in cows on their third lactation (338.43), followed by those on the second (322.61) and fourth lactations (308.66).

The effect of month on SCC in raw milk shows a higher presence of SCC in December (469.00), followed by November (426.74), and October (401.14), respectively (Table 5).

Table 4. Influence of different cow lactation number on somatic cell count in raw milk (SCC/mL)

Effects	Somatic cell count per farm (SCC/mL-in 000)		
	N	LSM ± SE	SD
Effect of lactation Number in SCC			
Fits lactation	952	178.45 ± 15.84 [c]	391.36
Second lactation	443	322.61 ± 23.21 [a]	654.49
Third lactation	368	338.43 ± 25.47[a]	599.39
Fourth lactation	232	308.66 ± 32.08 [ab]	436.14
>Fifth lactation	208	205.61 ± 39.89 [bc]	192.93
Analyses of variance	Df	Pr>F	
Effect of lactation	4	<0.0001	

Number of samples (N); Least square means (LSM); Standard error (SE); Standard deviation (STD DEV); Analyses of variance (Pr>F), Degree of freedom (Df).

During August, September, January, February and March, this number seems to be lower (125.06, 147.12, 297.55, 276.64 and 153.65) and milk can be ranged as extra and first class quality milk.

Results from Fig. 1 show that there are also major differences between the months regarding the partition of milk quality as total according to milk quality standards for the somatic cell count (SCC/mL) in Kosovo in 2008.

From the total amount of milk produced in this period, the largest quantity is of extra quality and this variation ranges from 74.17% in October to 60.00% in February. A considerable amount of milk is what is known as poor hygiene milk and based on milk quality standards regarding SCC it ranges from 13.98 to 23.91%. In general the 1st, 2nd and 3rd class of milk quality account for <1.50 and >7.00% of milk, with small variations between months throughout the entire research period.

The analyses of results, considering the same milk quality production regarding SCC, compared to SCC for milk standards in 2007, 2008 and 2009 are shown in Fig. 2.

It is noticeable that because of enforced standards (based on EU standards for milk quality) there is a negative curve for milk quality from extra class milk towards low quality because of somatic cell presence through the period 2007-2009. Regarding standards implemented in 2007, those that are being implemented in 2008 and those that are expected to be implemented in 2009, a large amount of milk based on these standards is classed as extra quality milk.

Table 5. Influence of month of year in somatic on somatic cell count in raw milk (SCC/mL)

Effects	Somatic cell count per farm (SCC/mL-in 000)		
	N	LSM ± SE	SD
Effect of month in SCC			
September	237	147.12 ± 31.05 ^{cd}	218.99
October	334	401.14 ± 31.25 ^{a}	657.52
November	393	426.74 ± 34.41 ^{a}	603.42
December	398	469.00 ± 33.97 ^{a}	661.79
January	418	297.55 ± 35.83 ^{b}	393.93
February	423	276.64 ± 37.67 ^{b}	451.71
Analyses of variance	Df	Pr>F	
Effect of month	7	<0.0001	

Number of samples (N); Least square means (LSM); Standard error (SE); Standard deviation (SD); Analyses of variance (Pr>F), Degree of freedom (Df).

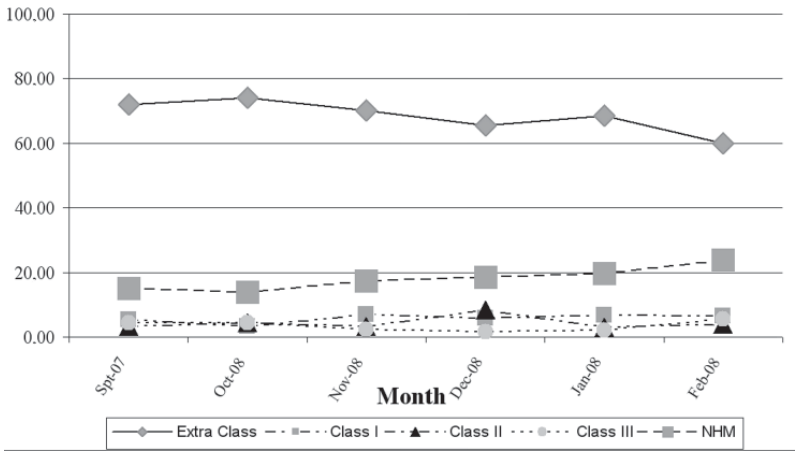

Fig. 1. Milk quality share as a total according to milk quality standards for somatic cell count (SCC/mL) in 2008 in Kosova. *NHM - non-hygienic milk

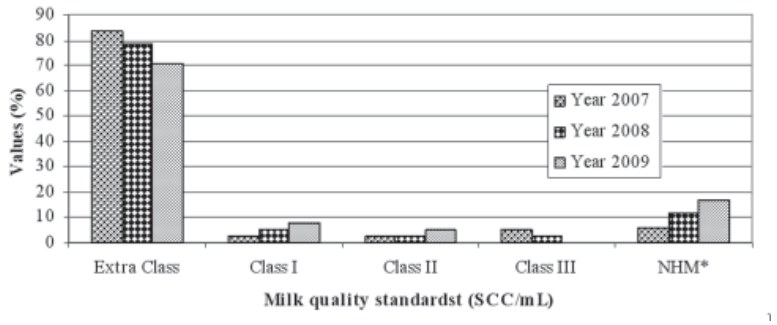

Fig. 2. Distribution of milk quality classes produced during study period with milk quality standards for somatic cell in milk (SCC/mL) per year 2007, 2008, 2009, in Kosova. *NHM - non hygienic milk.

In 2007 extra quality milk accounts for 83.39% of total milk produced, in 2008 this decreased to 78.45% and in 2009 it was 70.88%. So the amount of what is called non-hygienic milk or milk which is not accepted as fresh quality milk because of the high SCC count increased from 2007-2009.

Discussion

The results attained lead us to the conclusion that the amount of somatic cells (SCC) in raw milk from the diary farms included in this study is relatively acceptable according to the standard in the country taking into consideration the large managerial divergence, breeds, farm infrastructure, and the present structure of animal health control in the country.

However, we should not underestimate the multi-dimensional negative effect that presence of SCC might have on overall management and animal health. If milk quality production trends continue in this way, always compared to standards for raw milk quality, then 11.31% (SCC/mL<400.000) will not meet the standards for raw milk in 2009. Huge variations were noticed for SCC in different dairy farms in Kosovo. Milk produced in August contained three times less SCC than milk produced in December by the same cows, which might be caused by the failure to provide good management (i.e., lack of ventilation, stress, etc) increasing the risk of environmental pathogen intramammar infection (WENZ et al., 2007).

Considering the large variations in terms of management between different dairy farms in Kosova (BYTYQI et al., 2005 and 2008), the decrease in somatic cells in milk is an important indicator with positive multifactor effects (economical, food security, animal

health improvement, etc). The large differences between the different farms included in our study show managerial divergences in many aspects which in most cases are not only related to expensive infrastructure (closed milking system, etc.) but derive directly from negligence of proper managerial practices.

From the results of this study a negative genetic tendency may also be seen between cow breeds with high productive potential (e.g. HF and BS) and the high presence of SCC in fresh milk. Though our results fully comply with those achieved by HERINGSTAD et al. (2000) and ØDEGÅRD et al. (2003), part of the real breed effect in this case might be included in different other variables (e.g. farm, month, etc.)

The expression of milk quality for the study period in Figure 1, shows fairly linear trends between extra class milk and non-hygienic milk throughout the entire period.

From the total milk produced, most of the time there was a higher proportion of extra quality milk and a lower proportion of the non-hygienic milk.

In regard to SCC, good managerial practices and proper intervention in the infrastructure of the diary farms can have a positive effect, transforming non-hygienic milk standard into extra class, 1st, 2nd and 3rd class, respectively, in Kosovo.

Certainly, assuring quality data and including more farms in data collection for SCC, are key factors for improving milk quality, animal health and increasing farm profitability in Kosovo.

Conclusions

The information from our study includes only part of the possible consequences caused by SCC. It is necessary to include more variables that in one way or another may have an effect on the presence of SCC, proper handling and on time analyses of milk samples, involve more farmers and disseminate the results to farmers in the fastest way regarding SCC, in order to have a better understanding of raw milk quality from the mammary gland up to the processing unit.

Whatever the case, this study could be considered the right approach in preventing possible causes that lead to an increase of SCC in milk, comparing current milk production with existing quality standards and thus, improving animal health (e.g. identification of subclinic mastitis at early stages), consumer security (high quality milk) and farmers' profit (bonus-price, prevention of disease, etc).

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SAŽETAK

Glavni cilj istraživanja bio je odrediti utjecaj broja somatskih stanica u mililitru na kakvoću sirova mlijeka na nekim gospodarstvima mliječnih krava na osnovi postojećih normi za kakvoću sirova mlijeka u Kosovu. U razdoblju od kolovoza 2007. do veljače 2008. laboratorijski su bila pretražena 2203 pojedinačna uzorka mlijeka. Model GLM bio je upotrijebljen za analizu učinka različitih varijabli na broj somatskih stanica u sirovom mlijeku. Učinak svih varijabli smatran je trajnim. Sveukupni rezultati pokazuju da su veličina stada ($P<0,0001$), pasmina ($P<0,0004$), mjesec u godini ($P<0,0001$) i broj laktacija ($P<0,0005$) značajno utjecali na broj somatskih stanica. Sukladno postojećim zakonskim odredbama s obzirom na kakvoću sirova mlijeka za 2008. i 2009. godinu polučeni rezultati pokazuju da će, zadrži li se kakvoća proizvedenoga mlijeka na istoj razini, oko 78,45% za 2008. i 70,88% za 2009. biti mlijeko iznimne kakvoće (broj somatskih stanica/mL<300.000, odnosno<200.000). S druge strane oko 11,31% za 2008. i 16,61% za 2009. uzoraka mlijeka bit će slabe kakvoće, tj. izvan standarda (broj somatskih stanica/mL<600.000 odnosno<400.000). Premda je broj somatskih stanica u sirovom mlijeku pretraženih krava zasada relativno nizak, njegov nalaz nipošto ne smije biti potcijenjen imajući na umu da visoka stopa povećanog broja somatskih stanica u uzorcima sirova mlijeka negativno utječe na dobit stočara, na sigurnost hrane za potrošača i općenito na zdravlje životinja.

Ključne riječi: sirovo mlijeko, broj somatskih stanica, kakvoća mlijeka