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The quality of goat milk and hygiene management practices on farms in Vojvodina

Snezana Paskas[1*], Jelena Miocinovic[2], Mila Savic[3], Branislav Vejnovic[3] and Zsolt Becskei[3]

[1]*University of Novi Sad, Faculty of Agriculture, 21000 Novi Sad, Serbia*
[2]*University of Belgrade, Faculty of Agriculture, 11000 Zemun-Belgrade, Serbia*
[3]*University of Belgrade, Faculty of Veterinary Medicine,11000 Belgrade, Serbia*
[*]*Corresponding author:* snpaskas@gmail.com

Abstract

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The present work aimed to study the goat farms concerning different hygiene-sanitary and health management practice. Also, bulk tank milk of Alpine breed goats was used to investigate changes in the composition of milk during lactation on six farms in Vojvodina Region. The results showed that although 96.67% of farmers were familiar with mastitis, approximately 56.67% of farmers reported a lack of knowledge about subclinical mastitis and therefore not intensely monitoring udder health during the lactation period. Somatic cell count (SCC) and total bacteria count (TBC) were the most variable traits in our research and lactation average SCC between investigated farms showed a significant difference ($P < 0.01$) (a range from 1088×10^3/ml to 3129×10^3/ml). At the same time, TBC was found in a wider range, from 66×10^3/ml to 3508×10^3/ml. Furthermore, SCC and TBC often did not meet the recommended quality level. Therefore, during the entire lactation period, 63% of the milk samples contained above 1.5 million SCC/ml and 37% of the samples were contained TBC above 1.5 million CFU/ml. Results also confirmed considerable seasonal variations of goat milk composition and the milk fat was the component that most varied (cv: 33.16%). It was observed that organic in comparison to conventional milk chemical composition, was significantly different, especially in terms of protein content ($P < 0.0001$). In conclusion, goat dairy production could be of considerable importance in Vojvodina but dairy goat sector requires a more systemic approach, better hygiene milking conditions and implemented prevention and control programmes during the milking routine.

*Keywords:*goat milk; milking practices; chemical composition; SCC; TBC
Abbreviations: SCC – somatic cell count; TBC – total bacteria count; CFU – colony-forming unit; TS – total solids; SNF – solids-non fat;

Introduction

Compositional profile and hygienic quality of raw goat milk are of utmost importance for successful production of dairy goat products. The proper hygienic and nutritional goat milk quality enlightens not only its potentials and values but at the same time the value of its speciality products (cheese, cream, and yoghurt). There can be no quality goat milk speciality products if there are no healthy goats for milking, hygienic procedures, and good manufacturing practices (Ribeiro and Ribeiro, 2010). Many comparative studies have shown differences and high variation in nutritional, chemical, and rheological compositions between and within goat products, due to the multiplicity of manufacturing procedures, localities, animals, and management factors (Park, 2011). Therefore, the goat milk industry will be virtually dependant on the establishment of high producing dairy goat herds, production of high-quality milk (Yangilar et al.,

2013) and milk with particular nutritional/dietary characteristics (Greppi et al., 2008). Some of the positive features of goat milk as a nutritional media, or as a source of food for nutritional formulas for humans can be intuitively predicted from its composition (Silanikova et al., 2010). However, the composition of goat's milk is greatly differed (Yangilar et al., 2013), especially in different European areas and it is very important better knowing of the raw material characteristics before developing new products (Morgan et al., 2003). The safety of raw goat milk is therefore primarily dependent upon the control of risk factors on-farm to minimize the opportunity for microbiological hazards to contaminate raw milk.

The number of microorganisms in milk mostly depends on milking hygiene, which includes staff, animals, facilities, hygiene maintenance, and cleaning of the equipment. It also depends on the health of the udder and the presence of mastitis (Kompan and Komprej, 2012). Somatic cell count (SCC) is an important index for milk quality and in many countries it is used as a criterion for milk payment to producers, penalizing goat milk that contains more than 1×10^6 cells/ml (Salama et al., 2003). The total SCC is important in monitoring udder health and quality of milk, but in dairy goats, the relationship between bacterial infections and SCC values is not as simple as in dairy cows since non-infectious factors also have a big impact on SCC values (number of lactation, prolificity, milking routine, seasonality, and food) (Jimenez-Granado et al., 2014). Furthermore, the stage of lactation always influences SCC (Haenlein, 2002).There is no standard limit value for SCC of raw goat milk in the EU (Csanadi et al., 2015). Contrary, in the United States the somatic cell count (SCC) standard is 1 million per ml for goat's milk (Park, 2011). Leitner et al. (2016) suggested that goat milk which contains more than 3.5×10^6/ml SCC cannot be considered as safe milk and cannot be accepted for human consumption. They are also recommended that for every breed, management, and dairy final product the SCC cut-off should be independently tested.

The dairy goat production has gained more importance during the last two decades in Vojvodina, Serbia (Paskaš et al., 2019). At the same time, the goat sector is highlighted by often variations in the number of farm animals. This may be explained with the low profitability of dairy goat farms and as well as low commercial availability of goat milk and its products (Petrović et al., 2017).Thus, considerable amounts of goat's milk produced in Vojvodina is typically processed into cheese directly at the farm and promoted as "farm cheese" or sold as whole milk.

The present study was undertaken to provide information on different management hygiene-sanitary practices on dairy goat farms in Vojvodina and identify potential management risk factors. Furthermore, the objectives of this study were to examine the influence of different production systems on chemical composition goat milk during lactation with a particular focus on SCC and total bacteria count.

Materials and Methods

Experimental sites and milk management practices

The survey was carried out on goat farms located in Vojvodina, north part of Serbia.The data were collected through a questionnaire from 60 randomly selected goat farms. Each farmer was surveyed about specific conditions of hygiene-sanitary management at the farm and preventive actions. Questions have been adapted to goat farming and mainly composed of closed questions what allows a simpler statistic treatment. These questions are either quantitative or qualitative: Yes/No questions or multiple choice question. They were filled out by the following records: general information (housing, breed, farm size and production system), feed management information, milking and hygiene practices and udder health.

Collection of milk samples

The second investigations involved five conventional and one organic farm. On each farm, samples of bulk milk were taken once a month (in regular monthly intervals (28±5days) throughout the lactation period of 9 months March-May (early), June-August (middle) and September-November (late lactation)). The farms were homogeneous in terms their main reared breed was French Alpine. The ages of the goat were mostly between 3 to 4 years and they had given birth 2 to 3 times. Goats were milked twice a day and at end of lactation switched to once a day. The goat farms were different size and systems as follows: Farm A-(FA): 900 lactating goats, organic, indoors (loose housing system); Farm B-(FB): 420 lactating goats, conventional, indoors (loose housing system); Farm C-(FC): 250 lactating goats, conventional, indoors (loose housing system); Farm D-(FD): 130 lactating goats, conventional, outdoors; Farm E-(FE): 48 lactating goats, conventional, indoors (loose housing system); Farm F-(FF): 22 lactating goats, conventional, indoors, (loose housing system).Goats had sufficient amounts of alfalfa hay and water was offered *ad libitum*. They received concentrate mixture twice daily at the milking time (in amount: FA; 300 g–400 g/day/goat, FB, FC, FD, 600–700 g/day/goat and FE, FF, 500 g/day/goat). During spring, summer and autumn the nutrition of goats on FD was based primarily on pasture (kept them indoors at night time).

Milk chemical analyses

Total of milk samples (n = 54) was analysed for chemical composition, according to standard methods. For the preservation of milk samples, Asidiol was used following ISO 13366-2:2006 and IDF 148-2:2006. Analyses were done in authorized laboratories with the MilkoScanFT+analyzer using the Fourier Transform Infrared-FTIR technique. MilkoScanTM+FT techniques comply with ISO 9622/IDF 141:2013 and AOAC official methods 972.16. For the determination of somatic cells in raw milk was used FossomaticFT FC (ISO 13366-2). BactoScanTM FC+ (ISO 16297) was used as a rapid method for determining the total number of bacteria (TBC) in raw milk. The analyses were conducted according to the procedures outlined by Foss Electric. Casein content was determined by the AOAC method (2000). The energy value was determined following Serbian Regulations (2013).

Statistical analysis

Depending on the values of coefficients of variation (cv), an appropriate method was chosen to test the difference between the groups. For homogenous datasets (cv < 30%) the groups were compared using one-way ANOVA followed by Tukey`s multiple comparison test and for heterogeneous datasets (cv > 30%) the groups were compared using Kruskal-Wallis ANOVA followed by Dunn`s multiple comparison test. Numerical data for homogenous datasets are presented as mean±standard deviation (Mean±SD) and for heterogeneous datasets as median values with corresponding interquartile range (IQR). Statistical analysis of the physicochemical milk results obtained in the investigation was carried out using statistical software GraphPad Prism version 6 (GraphPad, San Diego, CA, USA).

Results and Discussion

Milking hygiene management practice

General information obtained through asurvey of goat dairy farms in Vojvodina in terms of the number of animals and capacities is showed in Table 1. According to obtained results, 41.67% of inquired farms are keeping the goats on pasture and it is more practiced on small and medium-sized farms. Thus, the results as well show that hand milking is more associated with a low and medium herd size (26.67% and 13.33%, respectively). All farms milking activity done twice a day.

Table 2 shows the results of hygienic and health management practices on observed farms. Although 96.67% of farmers were familiar with mastitis, approximately 56.67% of farmers reported a lack of knowledge about subclinical mastitis and therefore not intensely monitoring udder health for the early detection of new mastitis cases. Furthermore, strip cup test, as a screening test for mastitis, was done on only 33.33% of observed farms and a total of 38.33% farmers not isolated goats with severe systemic mastitis. Early identification, monitoring and treatment of mastitis cases are extremely important. Subclinical mastitis is always related to low milk production, changes to milk consistency (density), reduced the possibility of adequate milk processing, low protein and high risk for milk hygiene since it may even contain pathogenic organisms (Sharma et al., 2011).

Bergonier et al. (2003) reported that goat subclinical mastitis prevalence ranges from 5 to 30%, although the prevalence of subclinical mastitis is usually being very low on well-managed goat farms (Paterna et al., 2014). Methods which are most commonly used for detection of sub-clinical mastitis are the California mastitis test (CMT) and somatic cell counts (SCC) but due to their low validity indices, these need to be subsequently combined with the more sensitive and specific, yet more costly, bacteriological or molecular methods (Paterna et al., 2014). Ajuda et al. (2013) reported that goats with asymmetric and asymmetric and pendulous udder had a significantly lower udder temperature and SCC was almost doubled than the SCC of the milk from goats with symmetric udders. In our research, 78.34% of farmers noticed some mammary gland abnormalities (deformities, asymmetric, asymmetric and pendulous udder, damaged teats etc.). Although SCC and TBC are the most often con-

Table 1. The general characteristic of investigated dairy goat farms in Vojvodina

Farm size, heads	Number of investigated farms	%	Housing		Milking		
			Indoors, %	Pasture, %	Hand milking, %	Machine (bucket system or pipeline), %	Milking frequency
18–50	22	36.7	23.3	13.3	26.7	10.0	2
51–100	12	20.0	10.0	10.0	13.3	6.7	2
101–200	13	21.7	10.0	11.7	6.7	15.0	2
> 200	13	21.7	15.0	6.7	3.3	18.3	2
Total	60	100.0	58.3	41.7	50.0	50.0	

Table 2. Health and hygiene management on investigated dairy goat's farms according to the different farm size

Variable	Yes (%)					No (%)				
	18–50	51–100	101–200	>200	Total	18–50	51–100	101–200	> 200	Total
Mastitis awareness	33.00	20.00	21.67	21.67	96.67	3.33	0.00	0.00	0.00	100.00
Awareness about the difference between clinical and sub-clinical mastitis	20.00	3.33	13.33	6.67	43.33	16.67	16.67	8.33	15.00	56.67
Mastitis clinical occurrence	13.33	13.33	10.00	16.67	50.33	23.33	6.67	11.67	5.00	46.67
CMT – California mastitis test	23.33	10.00	15.00	16.67	65.00	13.33	10.00	6.67	5.00	35.00
Group contagious mastitis goats in a separate pen	20.00	10.00	15.00	16.67	61.67	16.66	10.00	6.67	5.00	38.33
Strip cup test	1.67	8.33	13.33	10.00	33.33	35.00	11.67	8.33	11.67	66.67
Use single service towels	13.33	10.00	15.00	10.00	48.33	23.33	10.00	6.67	11.67	51.67
Wear gloves, (either nitrile or latex) during milking	3.33	1.67	0.00	0.00	5.00	33.33	18.33	21.67	21.67	95.00
Udder wash/Predip	26.67	13.33	18.33	15.00	73.33	10.00	6.67	3.33	6.67	26.67
Post-milking teat dipping	26.67	13.33	11.67	13.33	65.00	10.00	6.67	10.00	8.33	35.00
Mammary gland abnormalities	26.67	16.67	18.33	16.67	78.34	10.00	3.33	3.33	5.00	21.66
Control flies in the barn.	36.67	16.67	15.00	21.66	90.00	0.00	3.33	6.67	0.00	10.00
Provide clean, dry bedding in loafing areas	31.67	16.67	20.00	18.33	86.67	5.00	3.33	1.67	3.33	13.33
Regular cell count (SCC, TBC) testing (once a month)	0.00	3.33	6.67	11.66	21.66	36.67	16.67	15.00	10.00	78.34

sidered as raw milk quality measurements (Marphy et al., 2016) the regular monitoring of these parameters was implemented on only 21.66% surveyed farms. Thus, considering the appropriate hygienic practice during milking, post-milking teat dip was done by 65% of farms while using single service paper towels is practiced 48.33% of respondents. It is confirmed that using a post-milking teat dip appears to predispose some very low SCC herds to more clinical mastitis, in particular, mastitis caused by *E. coli* (Sharma et al., 2011). On the other hand, some activities such as fly control, udder wash and providing clean and dry bedding were practiced on the majority of surveyed farms. Hygienic milking has come into practice routinely to prevent the spread of *Staph. Aureus* inflicting contagious mastitis (Sharma et al., 2011).

Milk chemical composition

The seasonal variations of goat milk composition on six farms in Vojvodina are represented by Figure 1–6, while the average chemical composition, milk density and energy values are shown in Table 3.

All analyzed milk constituents were influenced by lactation period as well as different farm management. Such variations especially include fluctuations in the amounts of milk principal nutrients: total solids (TS), solids-non fat (SNF), milk fat and protein. Fat is the major component of milk and varies more widely than any other constituent. It showed the highest values of variability, in particular, the coefficient of variation was the highest for FE (cv: 33.16%). Contrary to this, a significant difference in average values between farms was not observed. The fat content of milk decreases for several weeks after parturition, riches the lowest values during the summer period and then increases, especially toward the end of lactation; concentrations range from 2.86% (FC) in middle to 5.25 (FE) in late lactation. Similar regularity was observed for concentrations of TS and SNF.

Although protein content changed over the whole period of lactation, the lowest values in early lactation were recorded for farms D and E. In most studies of milk quality over lactation are presented similar variability as in this study (Mayer & Fiechter, 2012; Bernacka, 2007; Borges et al., 2004). Compared to other farms, milk collected from the organic farm (FA) was significantly higher in TS, SNF and milk protein ($P < 0.01$; $P < 0.0001$). These effects are in accordance with previous research done by Silva et al. (2015). High-performance dairy goat breeds like Alpine goats can produce about 600 to 800 kg milk with 40 to 50 kg fat and protein per 240-days under organic farming standards but the milk yield is limited due to roughage quality and management (health, breeding) (Rahmann, 2009). Fewer variations during lactation in milk composition were observed on large conventional farms (B and C). In particular, we noted a smaller variability of milk fat content (cv: 14.58% and 8.54%, respectively).

No clear trends were observed for the lactose, especially ash content (Figure 1), neither from each of the six farms nor for the individual milk samples during lactation. In gen-

eral lactose in milk varies little (Kompan & Komprej, 2012), what complied with our research. Organic milk recorded lower average lactose content, a trend opposite to those observed for fat and protein contents. The mineral content of goat milk varies from 0.70 to 0.85% (Silanikova et al., 2010). Based on this study, higher values of milk ash was found in milk samples, especially collected from FE and FF (1.02%, in middle and 1.08%, in late lactation; respectively). Highly significant sources of variation ($P < 0.001$) were found for casein content. It is important to point out that milk collected from organic farm showed the highest casein variability (cv: 23.60%). Grosclaude & Martin (1997) reported that total casein content of French Alpine milk is about 2.2%. The present study demonstrated a higher means of casein (range: 2.24% (FD) to 3.71% (FA)). The milk chemical composition of goats keeping on pasture (FD) compared with other conventional, especially with small-sized farms, contained a slightly higher content of milk protein and therefore casein but significant differences did not occur. The studies also outlined that milk density was nearly constant throughout the lactation period.

Hygienic quality of milk

Results related to the variation of SCC and TBC during lactation are given in Figure 7. Goat milk bulk tank SCC on most farms showed a distinct seasonal variation and overall monthly mean SCC increased as lactation advanced, at levels ranging from 678×10^3/ml and 1005×10^3/ml in middle (FB and FC, respectively) to 5804×10^3 in late lactation (FA). Several studies have been conducted on the change in SCC with the stage of lactation, confirmed SCC increase with progressing lactation (Fekadu et al., 2005; Delgado-Pertinez et al., 2003;

Table 3. Average chemical goat milk composition in different farms systems

Farms/ Parameters		FA	FB	FC	FD	FE	FF	P
TS, %	Mean	13.37	11.78	11.39	12.08	12.00	12.22	**
	±SD	±1.55	±0.86	±0.85	±1.26	±1.53	±1.01	
	cv (%)	11.59	7.30	7.46	10.43	12.75	8.26	
SNF, (%	Mean	9.10	8.37	8.11	8.20	8.16	8.23	****
	±SD	±0.81	±0.41	±0.45	±0.42	±0.33	±0.44	
	cv (%)	8.90	4.90	5.55	5.12	4.04	5.35	
Milk fat, %	Mean	4.27	3.43	3.28	3.86	3.86	3.94	NS
	±SD	±0.80	±0.50	±0.28	±0.91	±1.28	±0.85	
	cv (%)	18.73	14.58	8.54	23.57	33.16	21.57	
Protein, %	Mean	4.32	3.07	3.12	3.14	2.94	3.07	****
	±SD	±0.96	±0.25	±0.29	±0.39	±0.22	±0.26	
	cv (%)	22.22	8.14	9.29	12.42	7.48	8.47	
Lactose, %	Mean	3.99	4.40	4.16	4.21	4.24	4.23	NS
	±SD	±0.47	±0.20	±0.28	±0.48	±0.32	±0.23	
	cv (%)	11.78	4.54	6.73	11.40	7.55	5.44	
Ash, %	Mean	0.80	0.88	0.84	0.86	0.92	0.99	NS
	±SD	±0.16	±0.24	±0.23	±0.12	±0.15	±0.13	
	cv (%)	20.00	27.27	27.38	13,95	16.30	13.13	
Casein, %	Mean	3.39	2.35	2.39	2.41	2.24	2.34	****
	±SD	±0.80	±0.21	±0.24	±0.33	±0.18	±0.22	
	cv (%)	23.60	8.94	10.04	13.69	8.03	9.40	
P/F, %	Mean	1.01	0.90	0.96	0.85	0.80	0.77	**
	±SD	±0.14	±0.07	±0.13	±0.21	±0.21	±0.20	
	cv (%)	13.86	7.78	13.54	24.71	26.25	25.97	
MD g/cm³	Mean	1.034	1.030	1.029	1.030	1.029	1.030	***
	±SD	±0.003	±0.001	±0.002	±0.001	±0.002	±0.004	
	cv (%)	0.29	0.10	0.19	0.10	0.19	0.39	
Energy value, cal/100 ml	Mean	74.03	60.83	58.58	64.12	63.60	65.29	*
	±SD	±11.03	±5.34	±5.99	±9.43	±12.22	±6.98	
	cv (%)	14.90	8.78	10.22	14.71	19.21	10.69	
Energy value, KJ/100 ml	Mean	309.07	254.24	244.97	267.69	265.45	269.66	*
	±SD	±45.81	±22.05	±24.93	±38.92	±50.33	±32.81	
	cv (%)	14.82	8.67	10.18	14.54	18.96	12.17	

TS – Total solids; SNF – solids non-fat; P/F – Protein/Fat; MD-Milk density; SD – standard deviation; cv – coefficient of variation

P: Statistic probability; *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$; ****: $P < 0.0001$; NS – not-significant

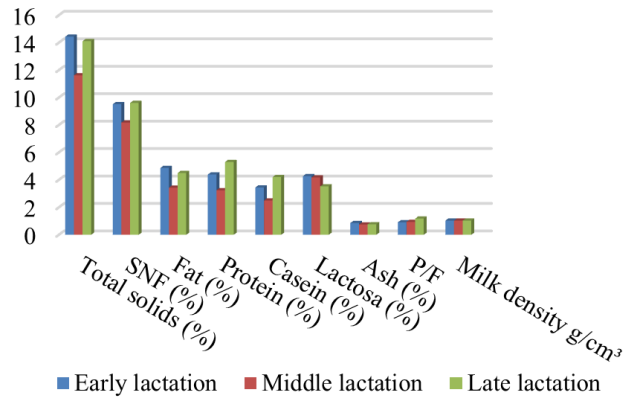

Fig. 1

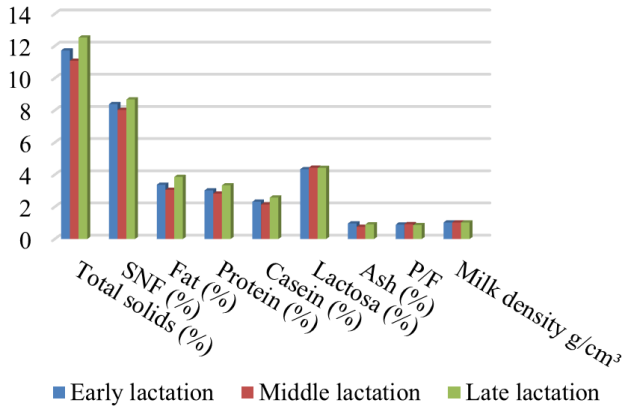

Fig. 2

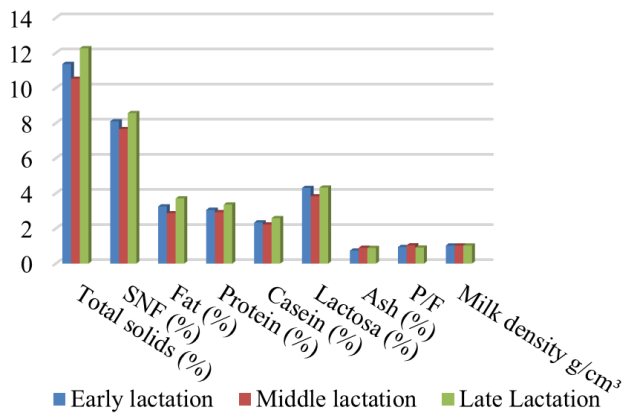

Fig. 3

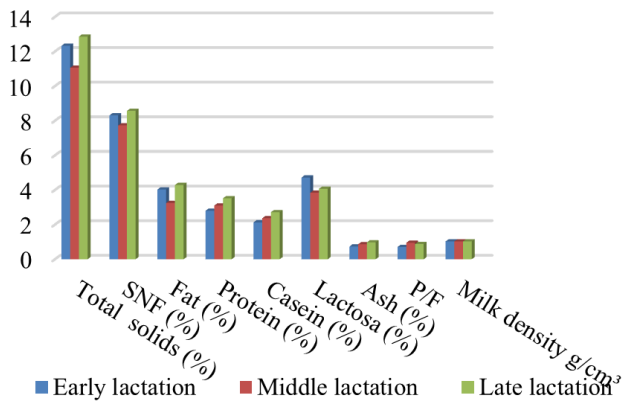

Fig. 4

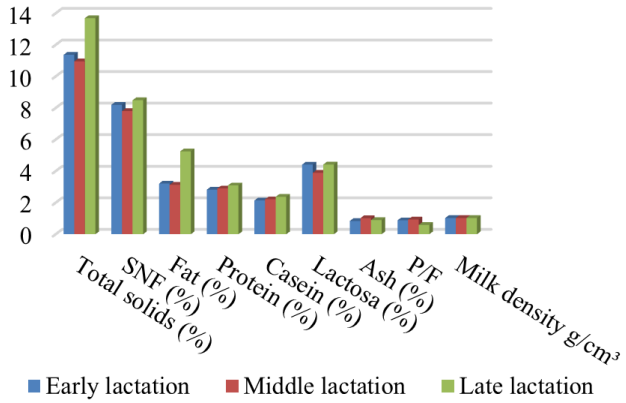

Fig. 5

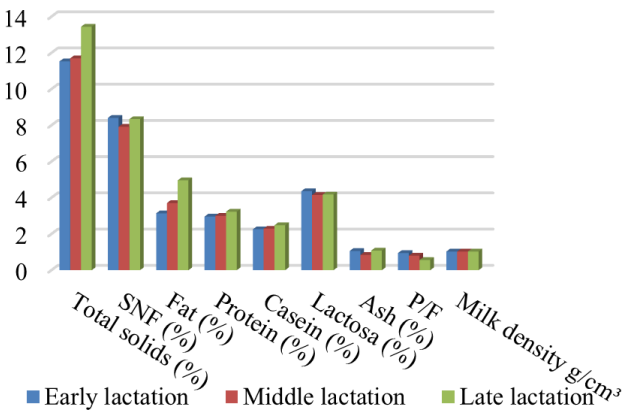

Fig. 6

Figures 1–6. Seasonal variations of chemical goat's milk composition (Farms: A, B, C, D, E and F)

Table 4. Average SCC and TBC in different farms systems

Farms /Parameters		FA	FB	FC	FD	FE	FF	P
SCC (x10³/ml)	Mean	3129	1088	1263	1599	1733	2914	**
	±SD	±3730	±823	±645	±808	±650	±1205	
	cv (%)	119.20	75.71	51.11	50.56	37.53	41.35	
TBC (x10³/ml)	Mean	1854	66	3067	3239	2378	3508	*
	±SD	±3162	±30	±2734	±3648	±3489	±4081	
	cv (%)	170.54	45.72	89.14	112.63	146.74	116.33	

SCC – Somatic cell count; TBC – Total bacteria count; SD – standard deviation; cv – coefficient of variation
P: Statistic probability; *: P < 0.05; **: P < 0.01

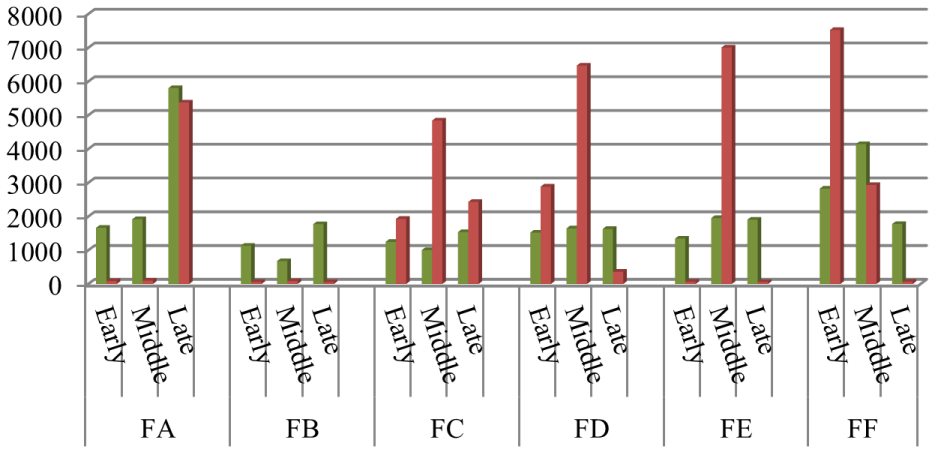

Figure 7. Seasonal variations of SCC and TBC on investigated farms (SCC, (*10³/ml); TBC, (* 10³/ml)

Zeng et al., 1997). In contrast, Bernacka (2007) reported higher somatic cell count per 1 ml in the 3rd and 4th month of lactation, in comparison to the milk obtained in the remaining months of lactation. This is similar to our results recorded for small conventional farms (FE and FF). Overall, it is observed that milk samples collected from most producers periodically showed poor hygienic milk quality and high values of SCC and TBC. Therefore, during the entire lactation period, 63% of the milk samples contained above 1.5 million SCC /ml and 37% of the samples were above limits of 1.5 million of the total bacterial counts. Considering the results of SCC and TBC values of organic milk it was observed that milk quality was satisfied in early and middle lactation but during the late lactation it showed the tendency of worsens. However, the values obtained in this study were determined to be higher than the values reported by Sliva et al. (2015) (mean SCC value below 1 million per ml). Therefore, their research suggested that organic management could be equivalent to conventional management with regard to the maintenance of animal health status, hygienic controls, and milk quality.

Mean SCC between investigated farms for the whole lactation showed a significant difference (P < 0.01) (a range from 1088×10³/ml (FB) to 3129×10³/ml (FA)) (Table 4.) This not corresponds well with previous findings done by Memiši et al. (2011) because their findings showed that French Alpine breed in the second and the third lactation possessed mean SCC values of 1.11×10³/ml and 1.36×10³/ml, respectively. No statistically significant differences were noticed among farms in the number of total microorganisms in milk although it is characterised by great variability. The microbiological quality of investigated goat milk samples mostly declines during the summer. This occurrence was specially recorded for farms C, D and E.

Conclusions

In summary, the results of the survey on conditions of hygiene-sanitary management highlight the different management systems. Related to the farm size, machine-milking is more used on farms with larger goat population as well

indicating more intensive milking management but at the same time more occurrence of clinical mastitis. On the other hand, small-sized farms more keeping goats on pasture and applied less adequate hygiene milking procedures connected with teat preparation, strip cup test and udder wash. High levels of SCC and TBC of some samples indicate a lack of good control of the sanitary situation of the animals and inadequate hygienic conditions. Milk nutrients, follow a pattern in which concentrations decline to a minimum during the summer months and slowly increase towards the end of lactation. From the technological point of view, investigated farms possessed the milk chemical composition of lower quality during the summer months. Based on the issues described previously, there is a reason to implement more stringent safety control system and regular monitoring of aspects related to subclinical mastitis (somatic cell count, total bacterial content) and milk chemical quality in the dairy goat industry in Vojvodina.

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