

COMPOSITION OF RAW MILK FROM CONVENTIONAL AND ORGANIC DAIRY FARMING

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Abstract: Possible differences between composition of raw milk due to dairy farming system (organic vs conventional) as well as seasonal variations were investigated. The samples were analysed during one year. A total of 6.782 samples of raw milk were collected (4.496 from organic farming). Dairy farms were located in the northern part of Republic of Serbia (Province of Vojvodina). The principle of analysis of raw milk samples was in accordance with the methodology by mid-infrared spectrometry and flow cytometry. The fixed effect of system of farming and season (winter, spring, summer and fall) have shown a high statistical significance ($P < 0.01$) on all examined milk parameters except fat, total solids and somatic cell count, where the impact was slightly lower ($P < 0.05$). Significant difference wasn't found in number of bacterial colonies ($P > 0.05$). Composition of milk is also affected by a number of other factors, therefore it is recommended to involve factors such as nutrition of dairy cows, breed and farm management.

Key words: milk composition, organic milk, conventional milk, dairy farming, Holstein- Friesian dairy cows

Introduction

Milk production in accordance with the principles of organic production demands that the livestock production system adapt to specific technology-in first line origin of feed, reproduction, health, welfare and behavior of animals (*Rosati and Aumaitre, 2004*). Organic agriculture has achieved a positive contribution to the preservation of the environment, reduction of arable land and residual pesticides and thus has a direct effect on the improvement of human health (*Bloksma et al. 2008*). Based on the available data it can be concluded that organic farming globally is growing fastest in the Europe (*FiBL & IFOAM, 2015*). The number of cattle in organic farming in the EU for the last decade had a growth rate of over 12%. The share of this production in 2014 accounted about 3% compared

to conventional cattle, the share of dairy cows accounted for about 0.7 million certified animals (*Eurostat data, 2014*). Organic raw milk compared with milk from conventional production has a better fatty acid composition i.e. contains more polyunsaturated fatty acids - PUFA with a higher proportion of omega-3 fatty acids and conjugated linoleic acid (CLA) (*Ellis et al. 2006; Prandini et al. 2009*). The mentioned group of fatty acids (especially omega-3) has positive effects on human health. Their activity is associated with improvement of neurological function (*Contreras and Rapoport, 2002*), decreases the risk of diabetes, prevents the occurrence of cardiovascular diseases, improves function of the immune system (*Paris, 2003; Wahl et al. 2004*). Besides the increased content its also important ratio between fatty acids (*Prandini et al. 2009*). Milk from organic production contains more α - tocopherol and vitamin A (*Pentelescu, 2009*). For determination of fatty acids (FA) content the gas-liquid chromatography is most often used. This method requires time-consuming procedure, expensive reagents, and qualified staff. The mid-infrared (MIR) spectrometry method could be a good alternative for assessing the fatty acid profile of dairy products (*Soyeurt et al. 2006*). On the nutritional value of milk, the most direct impact has a diet and method of rearing (*Slots et al. 2009; Stergiadis et al. 2012*). Diet and nutrition in organic farming are based on the increased using of pasture, grass silage, hay and less on the use of concentrates and maize silage. Therefore, a positive influence of nutrition can be expected on content and ratio of fatty acids, omega-3 fatty acids and CLA, lipophilic vitamins, β -carotene, lutein as well as high level of antioxidants (*Bloksma et al. 2008; Sakowski et al. 2012; O'Donnell et al. 2010; Popović-Vranješ et al. 2011*).

The aim of this paper is to investigate possible differences between composition of raw milk due to dairy farming system (organic vs conventional) as well as seasonal variations.

Materials and Methods

Animals and System of farming

Three conventional and one organic dairy farm located in the northern part of Republic of Serbia (Province of Vojvodina) were included for the twelve -month research. Dairy farms were distributed in different regions and housed from 100 to 900 Holstein-Friesian (black and red) dairy cows. All cows were loose housed-free stall stable. Cows in conventional farming (CF) were fed a total mixed ration (TMR) consisting mostly of maize silage, lucerne silage, straw, lucerne hay, concentrates, and mineral supplements. The feeding of the cows in organic farming (OF) was based on home-grown fodder and mainly grass and grass-clover products (including home-grown grains). In both of farming systems the composition of the

diet corresponded to the daily milk yield of cows, so that feed rations were completely balanced in accordance with the cow's needs.

Sampling and Instrumental analysis

Sampling of each cow's milk started in December 2014 and lasted until December 2015. All samples were delivered for analysis to the central laboratory for milk quality at Faculty of Agriculture Novi Sad. The laboratory is accredited in accordance with the international standard (ISO 17025). The collection of samples is carried out in compliance with the regulations of the International Committee for Animal Recording (ICAR- AT4). For preservation of milk samples Asidiol was used in accordance with ISO 13366-2:2006 and IDF 148-2:2006. A total of 6.782 samples of raw milk were collected, 4.496 of which were from OF and the rest from CF. The analyses of raw milk samples were carried out on the FOSS instruments-CombiFoss™ FT+. This device is a combination instrument consisting of the MilkoScan™ FT+ and the Fossomatic™ FC. The principle of measurement of raw milk samples is based in accordance with the methodology by mid-infrared (MIR) spectrometry method and flow cytometry (FC). The following parameters were analyzed: fat, protein, lactose, total solids, somatic cell count (SCC), number of bacterial colonies (CFU-colony forming unit), milk urea (MU), and contents of fatty acid (FA): Saturated (SFA), unsaturated (UFA), polyunsaturated (PUFA) and monounsaturated Fatty Acids (MUFA).

Statistical analysis

The data was evaluated by the *STATISTICA* statistical software (Ver. 10 StatSoft Company, 2011). The average values and variability of examined parameters as well as the effect of factors (system of farming and season as a fixed effect) on investigated milk traits were studied by means of the procedures PROC UNIVARIATE and PROC GLM-General linear model. The model equation used for the evaluation was as follows:

$$Y_{ijk} = \mu + S_i + R_j + e_{ijk};$$

where:

Y_{ijk} – dependent variable (fat, protein, lactose, total solids, SCC, CFU, MU, SFA, UFA, PUFA, MUFA);

μ – mean value of dependent variable;

S_i – fixed effect of the System i ($i = 1,2$);

R_j – fixed effect of the Season j ($j = 1,2,3,4$);

e_{ijk} – other random effects.

In order to properly adjust SCC and CFU parameters to normal distribution, logarithmic transformation was used as follows:

- 1) $SCC = \text{Log}_2 (SCC / 100000) + 3$
- 2) $CFU = \text{Log}_{10} (CFU)$

Results and Discussion

The results from the GLM model are given in Table 1. The fixed effect of system of farming (OF vs CF) and season (winter, spring, summer and fall) have shown a high statistical significance ($P < 0.01$) on all examined milk parameters except fat, total solid and somatic cell count (as a LogSCC), where the impact was slightly lower ($P < 0.05$). Significant difference wasn't found in the number of bacterial colonies ($P > 0.05$).

Table 1. The effect of system of farming and season on examined milk parameters

Source of variation	System OF vs CF	Season	System x Season
Parameters	F – value		
Fat	11.77*	75.83*	34.44*
Proteins	140.89**	46.94**	13.2**
Lactose	88.52**	45.84**	17.73**
T.Solids	17.15**	49.04*	62.81*
LogSCC	226.83*	3.59*	3.07*
Urea	336.07*	293.97**	29.58**
SFA	125.49*	57.89	21.65**
UFA	91.57**	64.69**	44.30**
MUFA	153.81**	108.83	35.71**
PUFA	55.67**	213.83	76.07**
LogCFU	0.47 ^{n.s.}	50.66 ^{n.s.}	11.25 ^{n.s.}

The results are in accordance with other studies comparing OF vs CF milks parameters (Kouřimská et al. 2014; Popović-Vranješ et al. 2014; Toledo et al. 2002). The average value of fat content (4.23 – 4.26%) has shown very small absolute differences between investigated type of farming. The fat content was slightly lower in OF which is in line with some studies (Hanuš et al. 2008; Nauta et al. 2006). Diet and breed have a major influence on milk fat content. Fluctuation of milk fat content and fatty acid composition is under great influence of these two factors (Jenkins and McGuire, 2006; Kelsey et al. 2003; Kučević et al. 2014).

Values of the coefficient of variation (CV) and standard deviation (SD) indicate that the variability of this trait is more under the influence of biological and breed characteristics of dairy cows, than rearing conditions present on the farms (*Kučević et al. 2011*). The protein content was significantly higher in organic milk while lactose and total solids were lower (Table 2).

Table 2. Results of analyses for raw milk parameters

Milk Components	Organic dairy farming				Conventional dairy farming			
	n	mean	SD*	CV(%)**	n	mean	SD	CV(%)**
Fat (g/100 g)	4496	4.23 ^a	0.65	15.1	2286	4.26 ^b	0.67	16.2
Proteins (g/100 g)	4496	3.53 ^A	0.37	11.2	2286	3.43 ^B	0.30	9.2
Lactose (g/100 g)	4496	4.59 ^a	0.20	4.4	2286	4.65 ^b	0.19	4.3
T.solids (g/100 g)	4496	13.12 ^a	0.80	6.1	2286	13.17 ^b	0.85	6.3
LogSCC	4493	2.86 ^a	1.22	43.1	2286	3.31 ^b	1.16	35.2
LogCFU	4496	4.89 ^{aa}	0.38	7.3	2286	4.88 ^{aa}	0.38	8.6
Urea (mg/dL)	4496	25.49 ^a	8.15	32.2	2286	29.21 ^b	6.51	22.3

Occurrence of the higher value of the proteins in the organic milk isn't expected because diet doesn't contain concentrate feeds. High content of raw protein in fresh and dried fodder probably influenced the amount of protein in the raw milk. In relation to these parameters, there is a lot of contradictory results in the literature. There are studies conducted between two systems of farming relative to comparison of the protein content. Results of these researches showed low content of protein in OF (*Kouřimská et al. 2014; Hanuš et al. 2008; Kuczynska et al. 2012*). Some studies show similar values or no difference in protein contents between organic vs conventional milk as obtained in our research (*Zagorska and Ciprovica, 2008; Butler et al., 2008*). In addition to already mentioned factors, important are impacts by sire, year of birth, length of lactation, calving season, breeding region etc. These factors also significantly affect milk yield, milk fat, and protein content in standard lactation - 305 days (*Petrović et al., 2006; Sekerden, 1997; Kučević et al., 2014*). These references are pointing to the fact that comparing the quality of milk in two different types of farming should include numerous genetic and paragenetic factors in research. Significant difference between systems of farming was found in the somatic cell count but not in the number of bacterial colonies ($P > 0.05$). Average number of SCC ranged from 97.441/ml (log 2.86) to 161.874/ ml (log 3.31) while average number of bacterial colonies were 97.400 /ml (log 4.89) to 128.73/ ml (log 4,88). In relation to the number of SCC numerous of studies showed opposite results and conclusion.

Toledo et al. (2002), Cermanova et al. (2011) found a lower SCC in organic milk while higher or no statistically significant difference of SCC was found by (*Kuczynska et al., 2012*). Right away after leaving the udder, the milk of healthy cows, kept in adequate breeding conditions, is almost sterile and contains the minimum number of microorganisms (8.933 CFU / ml) (*Kučević et al., 2013*). Inflammation of the mammary gland is accompanied by changes in the number of SCC, mainly as an increase in SCC in diseased quarters of udder (*Fregonese and Leaver, 2001*). By monitoring the change in SCC can successfully manage the health of the udder. Occurrence of diseases of the mammary gland is usually associated with low level of hygiene during the breeding and milking (*Schreiner and Ruegg, 2003*). To contamination comes mainly during and after milking (after leaving the udder) due to activity of microorganisms from the environment.

Statistically significant difference was found in milk urea (MU). The mean value of MU was higher in CF (29.21 vs 25.49 mg/dL). Our results are similar to the values for MU obtained by *Čobanović et al. (2015), Bastin et al. (2009)* and *Bandelja et al. (2011)* for Holstein breed. Higher values of MU indicate an imbalance of protein and energy, but MU concentration is also influenced by a whole range of factors (feeding, breed, stage and number of lactations, body weight, daily production and chemical composition of milk, somatic cell count, season and milking) (*Čobanović et al., 2015*). Considering that results of this study showed a higher protein content in raw milk and lower value of MU in OF. It can be concluded that cows in OF had greater access to highly degradable carbohydrates in the diet than the cows in the CF. The average content of saturated, unsaturated, monounsaturated and polyunsaturated fatty acids (FA) in the raw milk (organically and conventionally produced) is presented in Table 3. According to the results, it is evident that there was a highly statistically significant difference between dairy farming in all tested parameters.

Table 3. Concentrations of fatty acid in raw milk

FA (g/dL of Milk)	Organic dairy farming				Conventional dairy farming			
	n	mean	SD	CV(%)	n	mean	SD	CV(%)
SFA	4496	2.52 ^A	0.45	18.1	2286	2.64 ^B	0.46	17.2
UFA	4496	1.38 ^A	0.28	20.3	2286	1.29 ^B	0.29	22.1
MUFA	4496	1.55 ^A	0.23	15.5	2286	1.46 ^B	0.24	16.8
PUFA	4496	0.38 ^A	0.04	11.2	2286	0.37 ^B	0.03	9.3

Milk produced in organic dairy farming had a significantly lower concentrations of SFA (2.52 – 2.64) but more UFA (1.38 -1.29). On the other hand, participation of PUFA was higher in the organic milk (0.38 – 0.37). This ratio of FA in organic milk is preferred in terms of positive impact on human health. These

results are partially in compliance with *Ellis et al. (2006)*, *Popović-Vranješ et al. (2011)*. In their research recorded that conventional and organic milk didn't differ with respect to milk SFA content, but organic milk had a higher percentage of PUFA compared with conventional milk.

Seasonal variability in the composition of FA is highly expressed during the year. Data are presented in Figure 1 and 2.

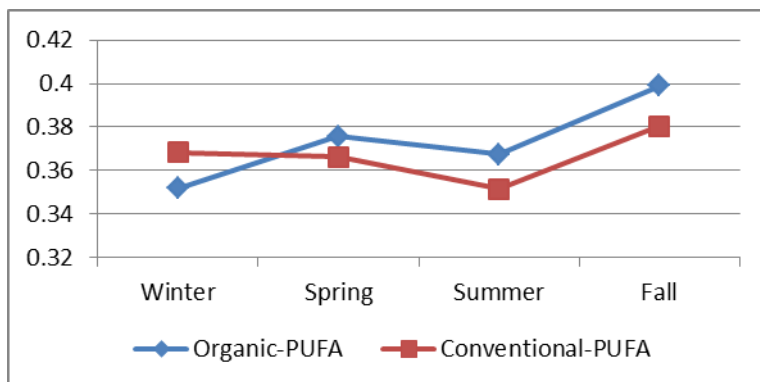


Figure 1. Seasonal variability of concentrations of PUFA in organic and conventional milk

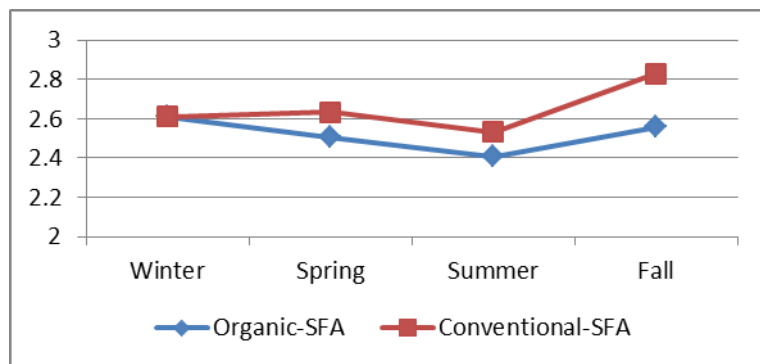


Figure 2. Seasonal variability of concentrations of SFA in organic and conventional milk

In organic dairy farming, the content of PUFA started increasing in late spring to early summer when the cows were put out on pastures or received fresh grass-clover products. Simultaneously with the increase of the content of PUFA, content of SFA in OF was gradually decreasing by the beginning of the fall. On the Figure 1 and 2 it can be clearly noted that the season identically affects conventional dairy farming too. A result of the effect of seasonality (variability by month of year) on milk FA content is in a line with other studies (*Ellis et al., 2006*; *Popović-Vranješ et al., 2011*; *Pentelescu, 2009*). All the authors pointed out that

FA content of milk is mostly influenced by nutrition. Using of TMR increased the proportion of milk SFA even during spring and summer. *Ellis et al. (2006)* emphasizes that knowledge of the effects of season, access to fresh grazing, or usage of specific silage types could be used by producers to enhance the content of beneficial FA in milk.

Conclusion

Composition of raw milk is affected by farming system (organic vs conventional), as well as seasonality during the year. Milk produced in organic dairy farming had a significantly lower concentration of saturated fatty acids but higher share of polyunsaturated fatty acids. This distribution of fatty acids in organic milk is preferred in terms of positive impact on human health. Composition of milk is also affected by a number of other factors. Therefore it is recommended to involve factors such as nutrition of dairy cows, breed and farm management during the comparison of conventional and organic dairy products. Regarding the diet of cows, special consideration should be given to the access to fresh grazing, silage type, cereal feeding etc., because nutritional factor takes a greatly impact on the composition of milk.

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Sastav sirovog mleka dobijen u sistemu konvencionalne i organske proizvodnje

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Rezime

Cilj rada je bio da se ispituju razlike između sirovog mleka dobijenog u različitim sezonama i sistemima proizvodnje (organska/ konvencionalna). Uzorci mleka su sakupljeni u toku čitave godine. Ukupno je sakupljeno 6782 (od čega 4496 iz organske proizvodnje). Farme su bile locirane na severnom delu Srbije (AP Vojvodina). Sirovi uzorci mleka su analizirani u skladu sa metodologijom infracrvene spektometrije i protočne citometrije. Fiksni uticaji sistema proizvodnje i sezone (zima, proleće, leto i jesen) su pokazali visoku signifikantnu značajnost (P

< 0,01) na sve ispitivane parametre mleka osim na mlečnu mast, ukupnu suhu materiju i ukupan broj somatskih ćelija, gde je uticaj bio signifikantan na nivou ($P < 0,05$). Statistički značajna razlika nije pronađena u ukupnom broju bakterija (kolonija) ($P > 0,05$). Na sastav mleka takođe utiče i veliki broj drugih faktora, stoga je za preporuku da se u ispitivanje uključe i faktori poput ishrane mlečnih krava, rase i farmskog menadžmenta.

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