

## The effect of different feeding system on fatty acids composition of cow's milk

Miroslav Juráček<sup>1</sup>, Patrícia Vašeková<sup>1</sup>, Daniel Bíro<sup>1</sup>, Milan Šimko<sup>1\*</sup>, Branislav Gálik<sup>1</sup>, Michal Rolinec<sup>1</sup>, Ondrej Hanušovský<sup>1</sup>, Renata Kolláthová<sup>1</sup>, Peter Kovár<sup>1</sup>, Norbert Andruška<sup>2</sup>

<sup>1</sup>Slovak University of Agriculture in Nitra, Faculty of Agrobiolgy and Food Resources, Nitra, Slovakia

<sup>2</sup>LEVMILK Levice, Slovakia

Article Details: Received: 2020-01-16 | Accepted: 2020-01-22 | Available online: 2020-03-31

<https://doi.org/10.15414/afz.2020.23.01.37-41>



Licensed under a Creative Commons Attribution 4.0 International License



The aim of the experiment was study the effect of different feeding system on fatty acids (FA) profile of cow's milk. The tank's samples from two farms were collected. On these farms breed: the Slovak Spotted cattle was reared. Feeding system was realized on the base pasture + supplementary feeding without silage – grazing feeding system (farm A) and silage feeding system (farm B). The FA profile in the milk samples with the apparatus (Agilent 6890A GC, Agilent technologies, USA) were analysed. Feeding system affects FA profile of cow's milk. Significantly higher proportion of FA in milk samples: C4:0, C17:0, C18:1 cis-n9, C18:2 cis-n9, C18:3-n3 and C20:0 in milk from grazing feeding system (farm A) was detected. The samples of milk only from this feeding system contained C20:5 n3. Significantly higher content of 18:2 cis n6 and presence of C13:0, C20:3 n6 and C20:4 n6 only in milk samples from silage feeding system were determined. Significantly lower proportion of saturated FA was typical for milk from farm A and significantly higher proportion of polyunsaturated FA was characteristic for the samples from farm B. The influence of the feeding system on the monounsaturated FA content was not confirmed. In milk samples from both feeding systems very different n6/n3 FA ratio was detected, with lower value for milk from grazing feeding system (1.36 vs. 9.12).

**Keywords:** dairy cattle, milk, fatty acids, feeding system

### 1 Introduction

Milk and dairy products are traditional foods in human nutrition (Haug et al., 2007; Kubíková and Habánová, 2012; Lorková et al., 2017). Milk contains water, lipids, FA, amino acids, proteins, minerals, and vitamins. It includes the available basic and essential nutrients needed for growth and development for the neonates in population of human's and animal's (Filipejová et al., 2010; Boro et al., 2016). Cow's milk has an average content of 3.5% proteins (80.0% caseins, 20.0% serum proteins), 3.0–4.0% lipids, 4.6% lactose, 1.0% ash (Ca, P, K, Mg, Na), vitamins (particularly thiamin, riboflavin, pyridoxine, tocopherol, retinol, carotenes) and 12.0% of dry matter (Muehlhoff et al., 2013). Slovak spotted breed, one from two national breeds in Slovakia, is combined meat-dairy utility type with medium to larger body frame, harmony structure of body and very

good musculature (Kadlečík et al., 2013). According to performance control in 2017 and 2018, the average utility of 6 626 and 6 843 kg of milk with average fat content of 3.95 and 3.93% and 262 and 269 kg production of fat, with an average protein content of 3.39 and 3.40% in protein production 224 and 233 kg for lactation (BSSR 2017; 2018). Genetic and non-genetic factors play a significant effect on the variations of milk yield and their components (Boro et al., 2016; Miluchová et al., 2014; Bujko et al., 2018). In terms of nutrition, not only is the fat content of milk but also its qualitative parameters forcefully on the content and ratio of FA is crucial. Cow's milk is an important source of saturated FA (Bagnicka et al., 2010; Gálik et al., 2011; Szwajkowska et al., 2011). The fat of bovine milk was often associated with cardiovascular disease because of saturated FA (Kajaba et al., 2009; Kalač and Samková, 2010). Changing the composition of FA is a long-term nutrition strategy.

\*Corresponding Author: Milan Šimko, Slovak University of Agriculture in Nitra, Faculty of Agrobiolgy and Food Resources, Department of Animal Nutrition, Tr. A. Hlinku 2, 949 76 Nitra, Slovakia. E-mail: [milan.simko@uniag.sk](mailto:milan.simko@uniag.sk)

The forages, although are low in fat content, are the main and cheapest source of unsaturated FA in ruminant nutrition. Current research is focussed on effects of different forages (fresh, silage, haylage) on fat content and FA profile in milk. Intake of pasture herbage rich on grassland and legume species positively affects ratio of FA (unsaturated/saturated) and increases content of conjugated linoleic acid (CLA) and vaccenic acid in cow's milk in comparison with milk from cows fed with conserved forages (hay or silage) (Kalač and Samková, 2010). Milk from cows grazed by pasture with wider biological diversity of plants contains lower portion of saturated FA, higher portion of polyunsaturated FA and it's characterized by lower n6/n3 FA ratio contrast to the milk from housed cows (Martin et al., 2002; Martin et al., 2004; D'urso et al., 2008).

## 2 Material and methods

### 2.1 Farm A: grazing feeding system

Farm A operates in Central Slovakia and cultivates 397 hectares of agricultural land in the foothills. The altitude is in the range from 400 to 700 m. above sea level. Annual average precipitation in the year 2016 was 750 mm and has a decreasing trend. The average annual temperature reached 8 °C. At the time of the realization of the experiment, 64 cows of Slovak spotted cattle were bred. Daily milk production was about 150 kg and for the entire herd 55,000 kg of milk per year. Milking was provided by Alfa Laval Agri no. 906601-82 series 415 MA, with frequency 2x daily.

### 2.2 Farm B: silage feeding system

The agricultural grange is located in the south of western Slovakia, a maize production area with an altitude of 150 m above sea level. The company managed 1,820 ha of agricultural land in 2016. Average annual precipitation reached 568 mm in 2016 and an average temperature of 9.6 °C. At the time of the research, on the farm were 280 pieces of dairy cattle – Slovak spotted breed with an average daily production of 5,000 kg and an annual production of 1,800,000 kg per year. Milking was realized twice a day in herringbone parlour Fullwood 2 × 10. Type of stabling – free.

### 2.3 Feeding

#### 2.3.1 Farm A: grazing feeding system

The dairy cows were grazed daily between 6:30 and 15:30. Pasture grassland was from a botanical point of view consisted of 53% of grasses dominated by *Trisetum flavescens*, 4% of legumes with predominant *Trifolium repens*, 40% of other meadow and pasture herbs and 3% of blank places. The botanical evaluation of grassland was

done by the method of reduced projective dominance ( $D$  in %) according to Regal (1956).

At the time off grazing, dairy cows were supplementary fed with a feed ration of 15 kg of meadow hay, 25 kg of fresh clover, 2 kg of feed mixture (50% wheat and 50% barley), and 0.5 kg of molasses. The intake of pasture, water and mineral block was *ad libitum*.

#### 2.3.2 Farm B: silage feeding system

Feed ration (on the base total mixed ration – TMR): maize silage 17 kg, protein-energy feed (residue of corn grain) 6 kg, 8 kg of sugar beet pulps, 8 kg of feed mixture, 2 kg of extracted rapeseed meal, 1 kg of straw and 1 kg of meadow hay was fed by dairy cows. Water intake and mineral block were *ad libitum*.

### 2.4 Sampling and laboratory analysis

Collection of tank's milk samples (200 ml) from both farms ( $n = 12$ ) was carried out on the 16<sup>th</sup> of June 2016 (summer feeding season). The content of crude fat and FA profile were analysed in the milk samples. Analyses in Laboratory of Quality and Nutritive Value of Feeds (Department of Animal Nutrition, FAFR, SUA in Nitra) were realized. The crude fat content after acid hydrolysis was determined by extraction according to the Soxhlet principle. For determination of FAME's (FA methyl esters) was used GC system Agilent 6890A (Agilent technologies). The GC system was equipped with split injection autosampler, DB 23 analytical column (length 60 m, diam. 0.250 mm, film 0.15 µm, Agilent technologies) and flame ionisation detector (FID).

### 2.5 Statistical analysis

Statistical evaluation of results was realized using one-way ANOVA by IBM SPSS v. 20.0. For evaluation of statistical significance between variables (FA and fat content) Tukey test was used.

## 3 Results and Discussion

Average content of fat in analysed milk samples was 3.38% from farm with grazing feeding system and 3.46% from farm with silage feeding system (Table 1.). Mendoza et al. (2016) also confirmed tend to decrease fat yields with increasing pasture in the diet of dairy cows. Significant ( $P < 0.05$ ) differences between milk samples in the content of butyric acid (C4:0) were found. The higher percentage (2.30%) was found in milk from grazed cows. In the myristic acid (C14:0) percentage, the higher ( $P < 0.05$ ) value was determined in the milk from silage system (12.01%) in comparison with the milk from grazing system (9.04%). Palmitic acid (C16:0) was detected as a major acid in the analysed milk samples from both feeding systems. Differences in palmitic acid

content were not statistically significant. Significance ( $P < 0.05$ ) was determined in heptadecanoic acid (C17:0) with higher concentration in samples from grazing system. Cow's milk is the richest source of oleic acid (24%) (Markiewicz-Keszycka et al., 2013). In C18:1 cis n9 (oleic acid) concentration, the higher ( $P < 0.05$ ) value was found in the milk from farm with grazing feeding system. Morales-Almaráz et al. (2017) confirmed that the concentration of 18:1 cis n9 increase in cow's milk with increasing grazing time. In linoleic acid (C18:2 cis n6), significant ( $P < 0.05$ ) differences were detected, with higher content in samples from silage feeding system. The TMR feeding system resulted in milk with

increased concentrations of C18:2 cis n6 in experiment of O'Callaghan et al. (2016) too. Guler et al. (2010) reported the average total CLA (conjugated linoleic acid) content in milk samples from Turkey 1.02% and Blaško et al. (2010) reported the average CLA content in summer cow's milk from 6 farms in Slovakia 0.08%. In our experiment, the concentration of CLA (C18:2 cis n9) had values 0.35 and 1.19%. Higher ( $P < 0.05$ ) CLA value in samples from grazing feeding system was determined. This is in agreement with the results of Alothman et al. (2019) and Rolinec et al. (2018). The predominant n-3 FA in milk fat of the majority of mammals is  $\alpha$ -linolenic acid (Markiewicz-Keszycka et al., 2013). Significantly

**Table 1** Fatty acid profile in cow's milk from different feeding system (g 100 g<sup>-1</sup> FA)

Trait	Grazing feeding system		Silage feeding system	
	mean	S.D.	mean	S.D.
C4:0	2.30*	0.05	1.83*	0.07
C6:0	1.55	0.01	1.78	0.16
C8:0	0.91	0.01	1.31	0.19
C10:0	1.93	0.01	3.37	0.39
C12:0	2.22	0.01	4.14	0.42
C13:0	n.d.	/	0.15	0.01
C14:0	9.04*	0.01	12.01*	0.20
C14:1	0.64	0.01	0.84	0.10
C15:0	1.43	0.01	1.37	0.13
C16:0	27.52	0.04	31.00	1.08
C16:1	1.62	0.01	1.44	0.35
C17:0	0.97*	0.01	0.62*	0.06
C18:0	11.09	0.04	9.05	1.10
C18:1 cis n9	24.60*	0.11	19.76*	0.92
C18:2 cis n6	1.94*	0.01	3.45*	0.03
C18:2 cis n9	1.19*	0.01	0.35*	0.02
C18:3 n3	1.29*	0.01	0.42*	0.01
C20:0	0.22*	0.02	0.14*	0.02
C20:3 n6	n.d.	/	0.13	0.02
C20:4 n6	n.d.	/	0.21	0.02
C20:5 n3	0.13	0.01	n.d.	/
PUFA	3.37*	0.01	4.20*	0.01
MUFA	26.85	0.11	22.04	1.36
SFA	59.17*	0.17	66.78*	1.44
n3/n6	0.73*	0.01	0.11*	0.01
n6/n3	1.36*	0.01	9.12*	0.33
Fat %	3.38*	0.01	3.46*	0.01

FA – fatty acids, PUFA: polyunsaturated FA, MUFA: monounsaturated FA, SFA – saturated FA, S.D. – standard deviation, n.d.: not detected, \* – the values with identical superscripts in rows are significantly different at  $P < 0.05$

( $P < 0.05$ ) higher content of  $\alpha$ -linolenic acid (C18:3 n3) in milk from grazing feeding system was found. Samples of milk collected from the farm with silage feeding system contained less arachidic acid (C20:0) compared to milk from the farm with different feeding system ( $P < 0.05$ ). Eicosapentaenoic acid (C20:5 n3) was detected only in milk from pasture fed cows. Presence of tridecanoic acid (C13:0), eicosatrienoic acid (C20:3 n6) and arachidonic acid (C20:4 n6) was determined only in milk samples from farm with silage feeding system. The polyunsaturated FA (PUFA) in cow milk represents small proportion, less than 3% of all FA (Lindmark-Månsson, 2008). Differently in the experiment, a PUFA portion of more than 3% in the milk from both types of feeding was found. The effect of different feeding system on PUFA was significant ( $P < 0.05$ ). Higher proportion of PUFA was determined in the milk of cows fed on the base of silage. Similar as in this study, Markiewicz-Keszycska et al. (2013) reported more than 4% of PUFA in cow milk. In MUFA content, non-significant ( $P > 0.05$ ) differences were determined. In saturated FA (SFA) content, a significant ( $P < 0.05$ ) lower content was found in milk samples from farm with grazing feeding system, consistent with Elgersma (2015). According to Hudečková et al. (2011) recommended n6/n3 FA ratio in human and animal nutrition is 5 : 1. Ratio of n6/n3 in samples from farm with grazing feeding system was under this recommendation and from different feeding system was above the recommend ratio (1.36 farm A and 9.12 farm B). The data were consistent with the results of Barca et al. (2018) where n6/n3 ratio was greater in milk of cows fed with TMR than in milk of grazing cows.

#### 4 Conclusions

Milk is an important source of nutrients in animal and human nutrition. Feeding system affects FA profile of cow's milk. Significantly higher proportion of butyric acid, heptadecanoic acid, oleic acid,  $\alpha$ -linolenic acid, arachidic acid in milk samples from farm with grazing feeding system (farm A) was detected. Conjugated linoleic acid was more than three times higher in milk from grazing system. Milk samples only from this feeding system contained the eicosapentaenoic acid. The results confirmed that in milk from farm with silage feeding system (farm B) significantly higher content of linoleic acid and presence of tridecanoic acid, eicosatrienoic acid and arachidonic acid was determined only in these samples. Significantly lower proportion of saturated FA was typical for the examined samples from grazing feeding system and significantly higher proportion of polyunsaturated FA was characteristic for the samples from silage feeding system. The influence of the feeding

system on the monounsaturated FA content was not confirmed. In milk samples from both feeding systems very different n6/n3 FA ratio was detected (1.36 vs. 9.12, milk from farm A vs. farm B).

#### Acknowledgement

Thanks to the project "The application of additives in animal nutrition for nutrients transformation improve with the accent on quality, safety and sustainability of animal production" no. 1/0474/19.

#### References

- ALOTHMAN, M. et al. (2019). The "grass-fed" milk story: understanding the impact of pasture feeding on the composition and quality of bovine milk. *Foods*, 8(8), 350.
- BAGNICKA, E. et al. (2010). Expression and polymorphism of defensins in farm animals. *Acta Biochimica Polonica*, 57(4), 487–497.
- BARCA, J. et al. (2018). Milk fatty acid profile from cows fed with mixed rations and different access time to pastureland during early lactation. *Journal of Animal Physiology and Animal Nutrition*, 102(3), 620–629.
- BLAŠKO, J. et al. (2010). Fatty acid composition of summer and winter cows' milk and butter. *Journal of Food and Nutrition Research*, 49(4), 169–177.
- BORO, P. et al. (2016). Genetic and non-genetic factors affecting milk composition in dairy cows. *International Journal of Advanced Biological Research*, 6(2), 170–174.
- BSSR. (2017). The breeding services of the Slovak republic, s.e. The results of dairy herd milk recording in Slovak republic year 2017. Retrieved January 7, 2020 from <http://test.plis.sk/volne/RocenkaMagazin/Rocenka.aspx?id=mlhd2017/>
- BSSR. (2018). Breeding services of the Slovak Republic, s.e. The results of dairy herd milk recording in Slovak Republic for year 2018. Retrieved January 7, 2020 from <http://test.plis.sk/volne/rocenkamagazin/rocenka.aspx?id=mlhd2018/>
- BUJKO, J. et al. (2018). The impact of genetic and non-genetic factors on somatic cell count as a monitor of udder health in Slovak Simmental dairy cows. *Acta fytotechnica et zootechnica*, 21(4), 166–168.  
<https://doi.org/10.15414/afz.2018.21.04.166-168>
- D'URSO, S. et al. (2008). Influence of pasture on fatty acid profile of goat milk. *Journal of Animal Physiology and Animal Nutrition*, 92(3), 405–410.
- ELGERSMA, A. (2015). Grazing increases the unsaturated fatty acid concentration of milk from grass-fed cows: A review of the contributing factors, challenges and future perspectives. *European Journal of Lipid Science and Technology*, 117(9), 1345–1369.
- FILIPEJOVÁ, T. et al. (2010). Evaluation of selected biochemical milk parameters of dairy cows and their correlations. *Potravinárstvo*, 4, 12–15.
- ĀÁLIK, B. et al. (2011). *Biotechnology and animal food quality*. Nitra: Slovak University of Agriculture in Nitra.
- GULER, G. O. et al. (2010). Fatty acid composition and conjugated linoleic acid (CLA) content of some commercial milk in Turkey. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, 16(Supplement-A), 37–40.

- HAUG, A., HØSTMARK, A. T. and HARSTAD, O. M. (2007). Bovine milk in human nutrition – a review. *Lipids in health and disease*, 6(25), 1–16.
- HUDEČKOVÁ P. et al. (2011). Plants oil in the diet for laying hens. In STRAKOVÁ, E. and SUCHÝ, P. (eds.): *9<sup>th</sup> Kabrt's dietetic days*. Brno: Tribun EU, 144–147. In Czech.
- KADLEČÍK, O. et al. (2013). Diversity of cattle breeds in Slovakia. *Slovak Journal of Animal Science*, 46(4), 145–150.
- KAJABA, I. et al. (2009). Role of milk and dairy products in prevention of cardiovascular distribution. In FATRCOVÁ ŠRAMKOVÁ, K. (eds.): *Zobor day and West Slovakia days about osteoporosis 2009*. Nitra: SUA in Nitra, 70–77. In Slovak.
- KALÁČ, P. and SAMKOVÁ, E. (2010). The effects of feeding various forages on fatty acid composition of bovine milk fat: A review. *Czech Journal of Animal Science*, 55(12), 521–537.
- KUBICOVÁ, Ľ. and HABÁNOVÁ, M. (2012). Development of milk consumption and marketing analysis of its demand. *Potravinárstvo Slovak Journal of Food Sciences*, 6(4), 66–72.
- LORKOVÁ, M. et al. (2017). Consumption of milk and dairy products in patients with cardiovascular disease. In GÁLIK, B. and ZELINKOVÁ, G. (eds.): *Proceedings of Slovak community for agricultural, forestry, food and veterinary sciences*. Nitra: SUA in Nitra, 98–107. In Slovak.
- LINDMARK-MÅNSSON, H. (2008). Fatty acids in bovine milk fat. *Food & Nutrition Research*, 2008, 52.
- MARKIEWICZ-KĘSZYCKA, M. et al. (2013). Fatty acid profile of milk-a review. *Bulletin of the Veterinary Institute in Pulawy*, 57(2), 135–139.
- MARTIN, B. et al. (2002). Variabilité de la teneur des laits en constituants d'intérêt nutritionnel selon la nature des fourrages consommés par les vaches laitières. *Rencontres Recherche Ruminants*, 9, 347–350.
- MARTIN, B. et al. (2004). Effects of grass-based diets on the content of micronutrients and fatty acids in bovine and caprine dairy products. In LÚSCHER, A. et al. (eds.): *Land use systems in grassland dominated regions. Proceedings of the 20<sup>th</sup> general meeting of the European grassland federation, Zurich: Hochschulverlag AG an der ETH*, 876–886.
- MENDOZA, A., CAJARVILLE, C. and REPETTO, J. L. (2016). Intake, milk production, and milk fatty acid profile of dairy cows fed diets combining fresh forage with a total mixed ration. *Journal of Dairy Science*, 99(3), 1938–1944.
- MILUCHOVÁ, M., GÁBOR, M. and TRAKOVICKÁ, A. (2014). Analysis of genetic structure in Slovak Pinzgau cattle using five candidate genes related to milk production traits. *Genetika*, 46(3), 863–875.
- MORALES-ALMARÁZ, E. et al. (2017). Parity and grazing-time effects on milk fatty acid profile in dairy cows. *Animal Production Science*, 58(7), 1233–1238.
- MUEHLHOFF, E., BENNETT, A. and McMAHON, D. (2013). *Milk and dairy products in human nutrition*. Rome: Food and Agriculture Organization of the United Nations (FAO).
- O'CALLAGHAN, T. F. et al. (2016). Effect of pasture versus indoor feeding systems on raw milk composition and quality over an entire lactation. *Journal of Dairy Science*, 99(12), 9424–9440.
- REGAL, V. (1956). Microscopic method for evaluating feed quality. In *Proceedings ČSAZV, Plant production*, 6, 31 – 40 (in Czech).
- ROLINEC, M. et al. (2018). Change of feeding affects fatty acids profile of goat's milk. *Journal of Central European Agriculture*, 19(4), 883–889.
- SZWAJKOWSKA, M. et al. (2011). Bovine milk proteins as the source of bioactive peptides influencing the consumers' immune system—a review. *Animal Science Papers and Reports*, 29(4), 269–280.