THE INFLUENCE OF FEEDING RAPESEED POMACE AND EXTRUDED FULL FAT SOYBEAN ON THE FATTY ACID PROFILE IN COWS MILK

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Abstract. The aim of the study was to evaluate the changes in the fatty acid (FA) profile in milk by the inclusion of rapeseed pomace and extruded full fat soybean in the diet of dairy cows on the housing period. The experimental materials comprised samples of milk from 30 lactating cows that were divided into 3 groups: control group cows were fed by a farm's total mixed ration (TMR); cows in experimental group 1 were fed by a farm's ration with rapeseed pomace (TMR+R); and cows in experimental group 2 were fed by a farm's ration with extruded full-fat soybean (TMR+S). All milk fat samples were split into 2 portions for the analysis. One portion was analysed for fat concentrations by infrared spectroscopy Lactoscope FTIR (FT 1.0. 2001; Delta Istruments, Holand). Identification and quantification of FA were performed by gas chromatography. Direct comparison of the products showed that the inclusion of rapeseed pomace into the diet of dairy cows increased the content of unsaturated fatty acids (UFAs), monounsaturated fatty acids (MUFAs), polyunsaturated fatty acids (PUFAs) and decreased the content of saturated fatty acids (SFAs), 4.06%, 4.55%, 1.66% and 2.3% respectively, in comparison with the feeding farm's total mixed ration ($P<0.05$). Inclusion of extruded full fat soybean into the diet increased the content of UFAs, MUFAs, PUFAs and decreased the content of SFAs, 6.89%, 5.12%, 16.44% and 3.91%, respectively, in comparison with the feeding farm's TMR ($P<0.05$). Among the long-chain MUFAs, oleic acid (C18:1(n-9)) was significantly affected by the treatment ($P<0.05$).

Keywords: fatty acid, rapeseed pomace, extruded full fat soybean, milk

Introduction

Ruminant milk fat is of unique composition among terrestrial mammals, due to its great diversity of component FA. The diversity arises from the effects of ruminal biohydrogenation on dietary UFAs and the range of FAs synthesized *de novo* in the mammary gland (Markiewicz-Keszycka et al., 2013). The UFAs are usually called 'healthy fats', especially for their impact on the level of cholesterol in blood (Haug et al., 2007; Arnould & Soyeurt, 2009). Milk contains a low concentration of beneficial UFAs, including conjugated linoleic acid (C18:2cis9trans11), α-linolenic (C18:3n-3) and oleic acids (C18:1cis9), which could be improved in milk through pasture feeding (Simopoulos, 2002; Nantapo et al., 2014). PUFAs decrease cholesterol content more strongly than MUFAs (Williams, 2000). Oleic acids (C18:1cis9), which belong to the n-3 family, have anticancer and antiatherogenic properties (Williams, 2000; Haug et al., 2007). Besides its effect on the cholesterol level, linoleic acid (C18:2cis9,12), the most important in the n-6 family, improves sensitivity to insulin and, thus, reduces the incidence of type 2 diabetes (Arnould & Soyeurt, 2009). Many researchers and commercial interests want to increase the levels of MUFAs and PUFAs in milk using different technological methods (Lock and Bauman, 2004).

The inclusion of rapeseed products to a diet of dairy cows changes the milk FA profile because lipids of rapeseed are highly unsaturated, with oleic and linoleic acids as the principal components (Chouinard et al., 1997; McNamee et al., 2002). According to Focant et al. (1994), extruded rapeseeds in the diet increase the concentration of long-chain FA (mainly C18:0, C18:1, and C18:2) in milk and decrease the concentration of palmitic acid (C16:0). Heat-treated full-fat soybean presents an interesting FA profile that can improve the quality of fat in animal products according to consumer demand of healthier foods (Chilliard et al., 2000).

By modifying diets of lactating cows, MUFA (C18:1) content can be increased by 50 to 80% and may approach 50% of milk FAs by feeding lipids rich in 18-carbon fatty acids (Chouinard et al., 1998). Feeding low roughage diets increases the proportion of C18:1 in milk fat and palmitic acid (C16:0) content in milk fat can be reduced by 20 to 40% (Gulati et al., 1997).

The aim of the study was to evaluate the changes in the fatty acid profile in milk by the inclusion of rapeseed pomace and extruded full fat soybean in the diet of dairy cows on the housing period.

Materials and Methods

Animals and diets

The experiment was conducted at the Practical Training and Testing Centre under the Lithuanian University of Health Science. Milk samples were collected 8 weeks during the housing period. The on-farm experiment was carried out on 30 lactating cows that were divided into 3 groups: control group, experimental group 1 and experimental group 2. The control group cows (n=10) were fed by the farm's total mixed ration (TMR). Cows of cxperimental group 1 (n=10) were fed by the farm's ration with rapeseed pomace (TMR+R). Cows of experimental group 2 (n=10) were fed by the farm's ration with extruded full-fat soybean (TMR+S). Cows were fed individually twice daily. The composition and feeding value of the diet for all cows are shown in Table 1

Table 1. **Composition and nutritive value of diet**

Feedstuffs	Group		
	Control (TMR)	Experimental 1 (TMR+R)	Experimental 2 (TMR+S)
Wheat straw, kg	2.0	2.0	2.0
Perennial grass haylage, kg	20.0	20.0	20.0
Compound concentrates for milking cows, kg	6.1	4.6	4.1
Fodder sugar, kg	0.2	0.2	0.2
Rapeseed pomace, kg	-	1.5	-
Soya bean (extruded), kg	-	-	1.5
Premix *Provimi*, g	200	200	200
NaCl, g	80	80	80
Chalk, g	150	150	150
Content 1 kg feed			
Net energy for lactation (NEL), MJ	6.47	6.50	6.67
Crude protein, %	16.5	17.9	18.2
Rumen nitrogen balance (RNB)	41.36	69.0	77.0
Crude fibre, %	20.45	20.78	20.53
Calcium ratio with phosphorus	2.73 : 1	2.41 : 1	2.60 : 1
TMR − diet based on the total mixed ration; R − diet based on TMR with rapeseed pomace; S − diet based on TMR with extruded full-fat soybean			

Sampling and analyses

The cows were milked twice a day at 5.00 AM and 5.00 PM in a cowshed tied to stalls. Samples of milk (100 mL) were taken once per week from evening milking, and in total 240 milk samples were analysed. All the milk fat samples were split into 2 portions for the analysis. The samples for the determination of milk fat were conserved with 2-bromo-2-nitropropane-1.3-diol (Bronopol; D&F Control Systems, Inc. USA) and the samples for the determination of milk fat fatty acids were not preserved. The conserved milk samples were refrigerated at 4ºC and sent to the laboratory to be analysed for fat concentrations by infrared spectroscopy Lactoscope FTIR (FT 1.0. 2001; Delta Istruments, Holand).

Identification and quantification of FAs were performed by gas chromatography employing capillary column and flame ionisation detection. The sample for FA analysis was prepared according to the procedures described in EN ISO 5509:2000 and EN ISO 661:1989. The chromatographic peaks were identified on the basis of comparison with retention times of a mixture of referent material (EN ISO 5508:1990) obtained from Sigma-Aldrich from a local dealer. The parameters of chromatographic analysis are presented in Table 2.

Table 2. **Parameters of chromatographic analysis of fatty acids**

Parameter	Value
Column	BPX –70, capillary column length 120 m, ID 0.25 mm, film 0.25 µm (FAME)
Detector	FID
Temperature	
- column	60ºC for 3 min, 20ºC/min to 200ºC, 40 min at 250ºC
- injection	260ºC
- detector	270ºC
Nitrogen flow	3 mL/min
Injection	0.2 µL
Instrument	GC-17A Shimadzu

We calculated the content of each relevant fatty acid as a percentage of the total fat in each sample.

The statistical analysis was performed using GraphPad Prism version 4.0 statistical package. Statistical significance was declared at P<0.05.

Results and discussion

The dietary effect on milk FA profiles is presented in Table 3. After the inclusion of rapeseed pomace into the diet of experimental group 1 and extruded full fat soybean into experimental group 2, the contents of butyric (C4:0), caproic (C6:0), caprylic (C8:0), decenoic (C10:1(n-6)), myristoleic (C14:1(n-5)), pentadecanoic (C15:0), stearic (C18:0), oleic (C18:1(n-9)), linoleic (C18:2(n-6)), mead (C20:3(n-6)) and arachidonic (C20:4(n-6)) acids increased, while the contents of capric (C10:0), lauric (C12:0), palmitic (C16:0), palmitoleic (C16:1(n-7)), heptadecanoic (C17:0), arachidic (C20:0) and eicosapentaenoic (C20:5(n-3)) decreased in comparison with the control diet (TMR). Among the long-chain MUFAs, C18:1(n-9) was significantly affected by the treatment (P<0.05). An increased content of C4:0, C18:0, C18:1, C18:2 and a decrease of C10:0, C12:0, C14:0, C16:0, C16:1 and C17:0 was also observed by Glasser et al. (2008) after feeding rapeseed oils, soybean seeds, and protected sunflower seed. Similar findings were reported by Focant et al. (1994), Komprda et al. (2000), Kudrna and Marounek (2006) and Veselý et al. (2009), who performed their studies on rapeseed dietary components.

In our study, the total content of SFA was higher in the control group (TMR) in comparison with experimental groups 1 and 2 (P<0.05). The total contents of UFA, MUFA and PUFA were higher in experimental groups 1 and 2 than in the control group (TMR) (P<0.05). Similarly, Komprda et al. (2000) reported significant increases in the total PUFA when feeding a diet with heat-treated rapeseed cake in comparison with the soybean meal diet. On the other hand, Kudrna and Marounek (2006) and Veselý et al. (2009) reported a more pronounced positive effect of feeding extruded soybeans on the above-mentioned values than that of feeding rapeseed cake.

Table 3. **The fatty acid composition of milk fat (mean±SD) from TMR and with rapeseed pomace and extruded full fat soybean fed cows**

Fatty acid (% of total fatty acids)	Group		
	Control (TMR) n=80	Experimental 1 (TMR+R) n=80	Experimental 2 (TMR+S) n=80
C4:0; butyric	4.03±2.86	4.53±2.63	4.09±2.52
C6:0; caproic	1.24±0.44	1.25±0.27	1.27±0.42
C8:0; caprylic	0.93±0.29	0.94±0.27	0.93±0.29
C10:0; capric	2.28±0.47	2.21±0.45	2.14±0.43
C10:1(n-6); decenoic	0.51±0.34	0.53±0.42	0.64±0.46
C12:0; lauric	3.04±0.68	2.82±0.61	2.84±0.56
C14:0; myristic	9.73±1.84	9.83±1.45	9.34±1.47
C14:1(n-5); myristoleic	1.21±0.42	1.29±0.36	1.23±0.39
C15:0; pentadecanoic	1.44±0.45	1.52±0.52	1.56±0.55
C16:0; palmitic	30.42±5.55	28.97±5.62	28.76±4.66
C16:1(n-7); palmitoleic	2.49±1.22	2.13±0.71	2.26±0.69
C17:0; heptadecanoic	1.21±0.88	1.15±0.51	1.12±0.48
C18:0; stearic	9.44±1.66	9.51±1.84	9.94±1.78
C18:1(n-9); oleic	25.13±5.4*	27.17±1.84*	27.19±3.62*
C18:2(n-6); linoleic	4.24±1.79	4.39±2.13	5.11±3.41
C20:0; arachidic	1.01±0.69	0.98±0.67	0.82±0.52
C20:3(n-6); mead	0.86±0.61	1.05±0.96	0.93±0.62
C20:4(n-6); arachidonic	0.83±0.5	0.92±0.54	0.87±0.55
C20:5(n-3); eicosapentaenoic	0.85±0.58	0.71±0.55	0.79±0.54
SFA	64.32±6.57*	62.87±4.89*	61.81±4.69*
UFA	35.68±5.33*	37.13±4.87*	38.19±6.84*
MUFA	29.66±4.09	31.01±3.40	31.18±3.53
PUFA	6.02±2.49	6.12±2.78	7.01±3.66
Total fat	4.25±1.02	4.22±0.62	4.23±0.67
SD − standard deviation; SFA − saturated fatty acids; UFA − unsaturated fatty acids; MUFA − monounsaturated fatty acids; PUFA − polyunsaturated fatty acids; * − P<0.05			

Conclusion

Direct comparison of the products showed that the inclusion of rapeseed pomace or extruded full fat soybean into the diet of dairy cows increased the content of UFA, MUFA, PUFA and decreased the content of SFA, in comparison with the feeding farm's total mixed ration (P<0.05). These feedstuffs can be used to modify the milk fat quality by increasing the proportions of beneficial FAs.

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References

1. Arnould V. M-R., Soyeurt H. Genetic variability of milk fatty acids. J. Appl.Genet. 2009. Vol. 50. P. 29-39.

2. Chilliard Y., Ferlay A., Mansbridge R.M., Doreau M. Ruminant milk fat plasticity: nutritional control of saturated, polyunsaturated, trans and conjugated fatty acids. Ann. Zootech. 2000. V. 49. P.181-205.

3. Chouinard P. Y., Girard V., Brisson G.J. Performance and profiles of milk fatty acids of cows fed full fat, heat-treated soybeans using various processing methods. J. Dairy Sci. 1997. V.80. P. 334-342.

4. Chouinard P.Y., Corneau L., Bauman D.E., Butler W.R., Chilliard Y., Drackley J.K. Conjugated linoleic acid content of milk from cows fed different sources of dietary fat. J. Anim. Sci. 1998. V. 76 (Suppl. 1). P. 233–238.

5. Focant M., Mignolet E., Matatu B., Legrand A., Givron C., Vanbelle M. Fatty acid composition of the milk modified by feeding extruded rapeseed to dairy cows. In: Proc. 45th Annu. Mtg. of European Association of Animal Production, Edinburgh, Scotland, UK. 1994. P. 114.

6. Glasser F., Ferlay A., Chilliard Y. Oilseed lipid supplements and fatty acid composition of cow milk: a meta-analysis. Journal of Dairy Science. 2008. V. 91. P. 4687-4703.

7. Gulati S.K., Byers E.B., Ashes J.R., Scott T.W. Effect of feeding different fat supplements on the fatty acid composition of goat milk. Anim. Feed Sci. Technol. 1997. V. 66. P. 159–164.

8. Haug A., Hostmark A.T., Harstad O.M. Bovine milk in human nutrition: a review. Lipids Health Dis. 2007. Vol.6. P. 25.

9. Komprda T., Dvo řák R., Such ý P., Fialov á M., Šustov á K. Effect of heattreated rapeseed cakes in dairy cow diet on yield, composition and fatty acid pattern of milk. Czech Journal of Animal Science 2000. V.45. P. 325-332.

10. Kudrna V., Marounek M. The influence of feeding rapeseed cake and extruded soyabean on the performance of lactating cows and the fatty acid pattern of milk. Journal of Animal and Feed Sciences. 2006. V.15. P. 361–370.

11. Lock A.L., Bauman D.E. Modifying milk fat composition of dairy cows to enhance fatty acids beneficial to human health. Lipids. 2004. V. 39. P. 1197–1206.

12. Markiewicz-Keszycka M., Czyzak- Runowska G., Lipinska P., Wojtowski J. Fatty acid profile of milk - A Review. Bull Vet Inst Pulawy. 2013. V. 57. P. 135-139.

13. McNamee B.F., Fearon A.M., Pearce J. Effect of feeding oilseed supplements to dairy cows on ruminal and milk fatty acid composition. Journal of the Science of Food and Agriculture. 2002. V. 82. P. 677–684.

14. Nantapo C.T.W., Muchenje V., Hugo A. Atherogenicity index and health-related fatty acids in different stages of lactation from Friesian, Jersey and Friesian x Jersey cross cow milk under a pasture-based dairy system. Food Chem. 2014. Vol.146. P.127-133.

15. Simopoulos A.P. The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed. Pharmacother. 2002. Vol. 56. P. 365-379.

16. Vesel ý A., Křížov á L., Třin áct ý J., Hadrov á S., Navr átilov á M., Herzig I., Fišera M. Changes in fatty acid profile and iodine content in milk as influenced by the inclusion of extruded rapeseed cake to diet of dairy cows. Czech Journal of Animal Science. 2009. V. 54. P. 201-209.

17. Williams C.M. Dietary fatty acids and human health. Annales De Zootechnie. 2000. Vol. 49. P. 165-180.

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