Assesment of bovine milk fat quality from the view of human health

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Abstract

A desirable fatty acids (FA) profile in milk contributes to the production of milk with higher added value. The aim of this study was to evaluate the quality of milk fat from the view of human health from cow´s milk under on farm conditions. The study was performed on individual milk samples collected from four dairy farms breeding Holstein cows. The diets used on those farms were based on maize silage, hay and supplemental mixtures containing rapeseed oil and cake (Farm 1), extruded full-fat soybean (Farm 2), rapeseed cake + extruded full-fat soybean (Farm 3) or flaxseed + soybean meal (Farm 4). Milk samples were taken from four average yielding cows per herd and were analysed on the content of FA in milk fat. Samples of feedstuffs were taken at the same time as milk samples and were analysed on the content of dry matter (DM) and basic nutrients. Based on the FA profile, sums of SFA, MUFA and PUFA were calculated as well as following selected indices of milk fat quality: atherogenic, thrombogenic, health-promoting indices and hypo-/hypercholesterolaemic ratio. Content of SFA ranged from 61.29 (Farm 1) to 68.36 g/100 g FA (Farm 3). The highest content of MUFA was in milk from Farm 1 (34.71 g/100 g FA) and the lowest in milk from Farm 3 (27.59 g/100 g FA). Content of PUFA was similar in Farms 1 and 3 and higher in Farms 2 and 4. AI ranged from 1.89 (Farm 1) to 2.77 (Farm 3). TI was similar in Farms 1, 2 and 4 ranging between 2.36 and 2.58 and high in Farm 3 being 3.56. The highest HPI was found in milk in Farm 1 and the lowest in Farm 3. HH ratio was high in Farms 1 and 2 being 0.93 and 0.84, respectively and low in Farms 3 and 4 (0.53 and 0.59, respectively).

Keywords: dairy cows, milk, fatty acid profile, milk fat quality, indices.

Introduction

Nutritional value and composition of milk fat can be affected through the nutrition of dairy cows. E.g. it is possible to significantly reduce the content of saturated fatty acids (FA) in milk fat (Shingfield *et al.*, 2008) or increase the content of the n-3 FA and conjugated linoleic acid (CLA) that may have cardiovascular health benefits and anticarcinogenic properties. Diet composition is the main factor that can cause changes in milk FA (Hanus *et al.*, 2018). Feeding oilseed products to lactating dairy cows, as one of the dietary strategies, can modify the FA profile in milk fat to obtain milk rich in unsaturated FA, especially n-3 PUFA and CLA, as e.g. flaxseed. Other oilseeds we could include in the feeding of dairy cows are soybean, rapeseed, sunflower seeds and lupine seeds and their products (Veselý *et al.*, 2009; Chilliard and Ferlay, 2004).

A targeted modification of the FA profile of milk fat can be used for the production of milk with higher added value. For evaluation of milk fat quality, some indices e.g. atherogenic index, thrombogenic index, health-promoting index or hypo-/hypercholesterolaemic ratio have been proposed (Ulbricht and Southgate, 1991; Chen *et al.*, 2004; Santos-Silva *et al.*, 2002). The aim of this study was to evaluate the quality of milk fat from the view of human health from cow´s milk under on-farm conditions.

Methods

The study was performed on individual milk samples collected from four dairy farms breeding Holstein cows. The diets used on those farms were based on maize silage, hay and supplemental mixtures containing rapeseed oil and cake (Farm 1), extruded full-fat soybean (Farm 2), extruded rapeseed cake + extruded full-fat soybean (Farm 3) or flaxseed + soybean meal (Farm 4). Samples of feedstuffs were taken at the same time as milk samples and were analysed on the content of DM and basic nutrients. The composition of diets that were used on farms are given in table 1.

Table 1: Composition of the diets of dairy cows on individual farms (g/kg DM).

Items	Farm 1	Farm 2	Farm 3	Farm 4
Maize silage	464.1	483.2	508.0	345.0
Meadow hay	79.0	82.0	-	-
Lucerne hay	-	-	92.0	86.0
Barley	121.3	127.6	106.4	198.8
Oat	123.1	129.3	106.4	142.0
Wheat	-	-	-	45.4
Extruded full-fat soya	-	89.4	67.2	-
Soybean meal	-	-	-	39.7
Extruded rapeseed cake	117.6	-	56.4	-
Rapeseed oil	5.5	-	2.1	-
Flaxseed	-	-	-	28.4
Sugar beet chippings	66.1	66.4	49.2	85.2
Sodium chloride (NaCl)	-	-	1.9	2.8
Dicalcium phosphate (DCP)	-	-	4.3	8.5
Limestone ($CaCO_3$)	-	-	4.4	8.5
Sodium bicarbonate ($NaHCO_3$)	-	-	1.1	0.6
Monosodium phosphate	-	-	0.2	1.1
Magnesium phosphate (MgP)	-	-	-	1.1
Premix (sum)[1]	23.3	22.1	-	-
Microelements and vitamin mixture	-	-	0.4	5.7
Rumen protected Met and Lys	-	-	-	1.38

[1]the premix contains (g/kg in supplemental mixture): sodium chloride 6; dicalcium phosphate 17; limestone 16; sodium bicarbonate 1; monosodium phosphate 2; magnesium phosphate 2; microelements and vitamin mixture 6.

Milk samples were taken from four representative average yielding cows per herd and were analysed on the content of FA in milk fat. FA from extracted milk fat were released in the form of fatty acid methyl esters which were separated using a gas chromatograph and detected with the flame ionisation detector as described previously (Veselý *et al.*, 2009). Based on the FA profile, sums of saturated (SFA), monounsaturated (MUFA), polyunsaturated FA (PUFA) were calculated as well as following selected indices of milk fat quality that describe the nutritional value of milk fat:

atherogenic index (AI; Ulbricht and Southgate, 1991):
AI = (C12:0 + 4 x C14:0 + C16:0) / ΣUFA;

thrombogenic index (TI; Ulbricht and Southgate, 1991):
TI = (C14:0 + C16:0 + C18:0) / ((0.5 x ΣMUFA + 0.5 x Σ(n-6) + 3 x Σ(n-3)) + (Σ(n-3) / Σ(n-6)));

health-promoting index (HPI; Chen *et al*., 2004):
HPI = (ΣMUFA + ΣPUFA) / (C12:0 + 4 x C14:0 + C16:0);

hypocholesterolaemic/hypercholesterolaemic ratio (HH; Santos-Silva *et al.*, 2002):
HH = (C18:1 n-9 + C18:2 n-6 + C20:4 n-6 + C18:3 n-3 + C20:5 n-3 + C22:5 n-3 + C22:6 n-3) / (C14:0 + C16:0).

Results and discussion

Effects of different types of forages and oilseed products on the FA profile in milk fat and nutritional indices are shown in the Table 2. In this study, the content of SFA ranged from 61.29 (Farm 1) to 68.36 g/100 g FA (Farm 3). The highest content of MUFA was in milk from Farm 1 (34.71 g/100 g FA) and lowest in milk from Farm 3 (27.59 g/100 g FA). The content of PUFA was similar in Farms 1 and 3, higher in Farm 4 and the highest in Farm 2 where extruded full-fat soybean was fed to dairy cows. The lipids of soybean are highly unsaturated (Chouinard *et al.*, 1997). Similarly, the content of PUFA in milk fat of cows fed extruded soybean was higher ($P<0.05$) in comparison to groups of cows fed diets supplemented with protected palm fat and rapeseed cake (Kudrna and Marounek, 2006). From the view of human health, a higher content of PUFA in milk fat is desirable. The consumption of n-3 PUFA-rich foods has hypolipidemic, antithrombotic and anti-inflammatory effects (Simopoulos, 1999). Because the milk FA profile can be modified through the animal nutrition, PUFA-enriched milk can have the potential benefits for human health. On the other hand, it can affect the technological properties of milk fat (Hanus *et al.*, 2018).

The high proportions of SFA in milk fat, such as C12:0, C14:0, and C16:0, are related to an increased risk of atherosclerosis (Bobe *et al.*, 2007). To evaluate the risk of cardiovascular diseases we calculated the atherogenic index (AI) that ranged from 1.89 (Farm 1) to 2.77 (Farm 3). Thrombogenic index (TI) showing the tendency to form clots in the blood vessels describes the relationship between the pro-thrombogenic (it is SFA) and the anti-thrombogenic FA (it is MUFA, n-6 PUFA and n-3 PUFA) (Ulbricht and Southgate, 1991; Garaffo *et al.*, 2011), so TI should be low. TI were similar in Farms 1, 2 and 4 ranging between 2.36 and 2.58 where cows were fed a supplemental mixtures containing rapeseed oil and cake (Farm 1), extruded full-fat soybean (Farm 2) and flaxseed + soybean meal (Farm 4) and it was high in Farm 3 being 3.56 where extruded rapeseed cake + extruded full-fat soybean were added to the diet of cows. The health-promoting index (HPI) is inverse of the atherogenic index, thus the highest HPI was found in milk in Farm 1 and the lowest in Farm 3. Further, the hypocholesterolaemic/hypercholesterolaemic ratio (HH) was calculated according to Santos-Silva *et al.* (2002). HH index was high in Farms 1 and 2 being 0.93 and 0.84, respectively and low in Farms 3 and 4 (0.53 and 0.59, respectively). It is supposed that milk fat with high AI and TI values may more likely contribute to development of atherosclerosis or coronary thrombosis in humans, whereas milk with high HPI index and HH ratio may have a protective effect against cardiovascular diseases (Rafiee-Yarandi *et al.*, 2016).

Table 2. Effects of different types of forages and oilseed products on the FA profile in milk fat and nutritional indices

FA and indices	Farm 1	Farm 2	Farm 3	Farm 4
SFA (g/100 g FA)	61.29	62.32	68.36	64.87
MUFA (g/100 g FA)	34.71	32.14	27.59	30.28
PUFA (g/100 g FA)	4.00	5.54	4.05	4.85
AI	1.89	2.07	2.77	2.35
TI	2.36	2.36	3.56	2.58
HPI	0.53	0.49	0.36	0.43
HH	0.93	0.84	0.53	0.59

Conclusion

Using indices for evaluation of milk fat quality allows us deeper insight into the impact of FA on human health. Results of our study showed that health properties of milk fat differed among farms and that dairy nutrition contributed greatly on the variability in milk FA profile.

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