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Research Article ***Open Access***

Fatty acid profile of cow's milk from regions of Małopolska available on the Polish market

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SUMMARY

The aim of the study was to compare the percentages of fatty acids in market milk from producers in different regions of Małopolska during the summer and winter. The study was conducted on pasteurized milk with a fat content of 3.2%, produced in six dairies in the Małopolskie Voivodeship. The products were designated as milk from mountainous areas (M1, M2, M3 and M4) and milk from other areas (M5 and M6). The fatty acid profile was determined using a gas chromatograph. The analysis took into account saturated fatty acids (SFA), unsaturated fatty acids (UFA), including monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), the content of hypocholesterolemic fatty acids (DFA) and hypercholesterolemic fatty acids (OFA), and the DFA/OFA and UFA/SFA ratios. The results indicate that drinking milk from local cows grazing in mountainous regions had a favourable health-promoting fatty acid profile. It contained more n-3 PUFAs, including α-linolenic acid C18:3 n-3, vaccenic acid C18:1 n-7, and CLA, than milk from cows from other regions of Małopolska. Milk from cows from mountainous regions also had significantly higher ($P<0.05$) DFA content and DFA/OFA ratios. Higher levels of desirable DFA acids and DFA/OFA ratios were found in drinking milk obtained during the summer.

KEY WORDS: cow's milk, market milk, fatty acids, dairy, season

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INTRODUCTION

The priority goal of animal breeding is to produce a large amount of food at minimal cost. Therefore, indigenous breeds of animals, including cattle breeds, with much lower productivity than high-producing animals, cannot meet the demands of breeders. At present, however, indigenous cattle breeds are not treated solely as food-producing animals. Due to their small populations but very good functional traits, most importantly the physicochemical parameters of their milk and meat, health, and longevity, they are protected as a gene bank, and they have additional significance for the environment, culture and history (Zapletal et al., 2018). A characteristic cattle breed of the southern region of Małopolska is the Polish Red breed. Milk obtained from cows of this breed is distinguished by high content of protein, fat and solids, has high biological value, and is highly suitable for cheese-making. When similar (traditional) feeding systems were used, the proportion of CLA was highest in the milk of Polish Red cows (2.24%) and significantly lower in the milk of White-backed (1.61%) and Polish Black-and-White (1.19%) cows (Litwińczuk et al., 2012; Barłowska and Litwińczuk, 2009). According to Radkowska (2013), the increased value of bioactive components, fat and vitamins is influenced by pasture feeding during the summer months. Of particular note are conjugated linoleic acid dienes (C18:2-LA), especially conjugated linoleic acid (CLA), which have invaluable benefits for consumer health. An increased proportion of these acids has been observed in milk from cows using pasture (Nałęcz-Tarwacka et al., 2009).

Heat treatment does not induce physical or chemical changes that would reduce the nutritional value of the milk fat (Rodriguez-Alcala et al., 2009; Molto-Puigmarti et al., 2011). Rodriguez-Alcala et al. (2014) observed that UHT sterilization (135°C, 30 s) and microwave pasteurization (650 W, 1.30 min) decreased the total level of C18:2 conjugated linoleic acid (CLA) in milk, but at the same time increased the percentage of t9t11 isomers of this acid. Similarly, dairy products are a rich source of CLA isomers, which are also formed during physical processes in milk processing (Kramer et al., 2004; Dopieralska et al., 2020; Paszczyk, 2022).

The aim of this study was to compare the percentages of fatty acids in market milk from producers in different regions of Małopolska, during the summer and winter seasons.

MATERIAL AND METHODS

The study was carried out on pasteurized milk with 3.2% fat, produced in six dairies in the Małopolskie voivodeship, Poland. Market milk from the dairies was pasteurized at 72–75°C/15–25 s. Products were designated as milk from mountainous areas (M1, M2, M3 and M4) and milk from other areas (M5 and M6). The study was carried out in summer (May to September) and winter (October to February). Sixty milk samples were analysed in duplicate.

The profile of fatty acids was determined by esterification, a method which involves dissolving 5 mg of fat obtained after extracting milk with a solvent mixture of chloroform ethanol (2:1) in 50 µl of toluene. After adding 100 µl of 2 N sodium hydroxide to the product, it was esterified in methanol for 20 minutes at room temperature. Then 0.5 ml of 14% BF_3 in methanol was added, and the reaction was carried out again at room temperature for another 20 minutes. The resulting esters were extracted with hexane, and 1 µl was injected onto a chromatograph (TRACE GC Ultra, Thermo Electron, Milan, Italy) with a flame ionization detector (FID), with the following parameters: FID detector temperature 250°C, dispenser temperature 220°C, column temperature

60°C (3 min) to 200°C – 7°C/min (200°C – 20 min), STABILWAX column (30 m × 0.25 mm × 0.25 μm), helium as a carrier gas (1 ml/min), split flow 10 ml/min. Fatty acids were identified by comparison with methyl ester standards: linoleic acid, conjugated methyl esters (Sigma-Aldrich Co., Germany) for CLA and Supelco 37 Component FAME Mix (Sigma-Aldrich Co., Germany) for other fatty acids (Ledouxa et al., 2005).

The analysis took into account saturated (SFA) and unsaturated (UFA) fatty acids, including monounsaturated (MUFA) and polyunsaturated fatty acids (PUFA), and the content of hypocholesterolemic (DFA) and hypercholesterolemic (OFA) fatty acids, as well as the calculated DFA/OFA and UFA/SFA ratios.

The results were analysed by the least squares method using the General Linear Model (GLM) procedure (SAS, 2014). The linear model included the dairy, season, and dairy × season interaction as fixed effects. Data were presented as least-squares means (LSM) and the pooled standard error of the mean, with the significance levels of the effect. The LSMs for the groups were compared using the Tukey–Kramer multiple comparisons post hoc test. Values at $P < 0.05$ were considered a significant difference.

RESULTS

The profile of fatty acids in market milk according to the dairy and the production season is shown in Table 1. Significantly higher ($P < 0.05$) percentages of CLA and α-linolenic acid C18:3 n-3, the precursor of health-promoting eicosanoids, were found in the milk of cows from mountainous regions compared to milk from cows from other areas. A significantly ($P < 0.05$) higher percentage of this acid was observed in milk samples obtained during the summer. Milk from cows from mountainous regions also contained significantly ($P < 0.05$) more C18:1 n-7 vaccenic acid than milk from cows from other areas, and its level was significantly ($P < 0.05$) higher during summer. This acid is a precursor to the formation of CLA isomers. The percentages of short- and medium-chain SFAs (C4:0–C14:0) in milk were similar and did not differ significantly ($P > 0.05$) between milk producers. Only the levels of C4:0 butyric acid and C6:0 caproic acid were significantly ($P < 0.05$) higher during the summer. The percentage of C16:0 palmitic acid was lowest in milk from mountainous regions and during the summer. Differences in the levels of these acids between both dairies and seasons were significant ($P < 0.05$). Table 2 shows fatty acids types and ratios depending on the dairy and the production season. There was a significantly ($P < 0.05$) higher percentage of PUFAs and especially n-3 PUFAs in the milk of cows from mountainous regions. Significantly ($P < 0.05$) higher levels of UFAs and MUFAs, as well as a more favourable UFA/SFA ratio, were found in M1 and M2 milk from these regions. The highest content of hypocholesterolemic fatty acids (DFAs) was noted in M1, M2 and M3 milk from mountainous regions, and their levels were significantly ($P < 0.05$) higher during the summer. M2, M3 and M4 milk from mountainous regions had the lowest and most favourable ratio of n-6/n-3 PUFAs and differed significantly ($P < 0.05$) from milk from other regions. There was no significant ($P > 0.05$) interaction between dairies and season (Tables 1 and 2).

Table 1.

Profile of fatty acids in market milk depending on the dairy and the production season (% of total fatty acids)

Fatty acid	Milk from Małopolska (Poland)						Season		SEM	P-value		
	Milk from mountain regions				Milk from other regions							
	M1	M2	M3	M4	M5	M6	Summer	Winter		M	S	M × S
n	10	10	10	10	10	10	30	30				
C4:0	2.93	3.04	3.04	2.99	3.01	2.92	3.27a	2.70b	0.11	0.875	<.001	0.983
C6:0	2.09	2.10	2.17	2.09	2.18	2.12	2.28b	1.99b	0.06	0.901	<.001	0.994
C8:0	1.39	1.38	1.41	1.37	1.43	1.41	1.47a	1.33b	0.03	0.893	<.001	0.925
C10:0	3.22	3.19	3.28	3.16	3.41	3.39	3.44a	3.12b	0.09	0.493	0.001	0.926
C10:1	0.34	0.34	0.34	0.34	0.33	0.33	0.33	0.34	0.08	0.947	0.102	0.638
C12:0	3.77	3.66	3.76	3.70	3.99	4.02	3.90	3.75	0.09	0.157	0.148	0.949
C14:0	12.44	11.21	12.65	12.71	12.70	12.76	12.64	12.24	0.38	0.405	0.369	0.462
C14:1	1.03	1.01	1.04	1.04	1.07	1.07	0.97a	1.11b	0.02	0.256	<.001	0.198
C15:0	1.26a	1.27a	1.36b	1.29ab	1.13c	1.12c	1.20a	1.27b	0.02	<.001	<.001	0.379
C16:0	31.57a	31.64a	32.41a	33.48ab	34.43b	35.29b	31.71a	34.69b	0.61	<.001	<.001	0.339
C16:1 n-9	0.45	0.49	0.48	0.47	0.51	0.51	0.58a	0.39b	0.03	0.847	<.001	0.998
C16:1 n-7	1.68a	1.71a	1.71a	1.69a	1.85b	1.95b	1.74a	1.79b	0.05	<.001	0.038	0.970
C17:0	0.53a	0.55a	0.58a	0.54a	0.50abc	0.47b	0.56a	0.50b	0.02	0.011	<.001	0.371
C17:1	0.31ab	0.31ab	0.35a	0.33abc	0.30bc	0.28b	0.29a	0.33b	0.01	<.001	<.001	0.430
C18:0	10.23a	10.28a	9.92ac	9.77ac	9.06bc	8.41b	10.05a	9.11b	0.26	<.001	<.001	0.674
C18:1 n-9	21.30a	21.10ac	20.11bc	19.80b	19.96b	20.00b	20.47	20.26	0.24	<.001	0.274	0.517
C18:1 n-7	2.20a	2.22a	2.13a	2.07a	1.52b	1.37b	2.05a	1.76b	0.01	0.001	0.026	0.850
C18:2 n-6 (LA)	1.65a	1.59ab	1.43b	1.48b	1.55ab	1.72a	1.57	1.57	0.03	<.001	0.856	0.425
C18:3 n-6	0.066	0.057	0.070	0.073	0.059	0.058	0.052a	0.076b	0.001	0.387	<.001	0.976
C18:3n-3 (ALA)	0.54a	0.57ac	0.68c	0.61ac	0.35b	0.28b	0.51	0.49	0.03	<.001	0.319	0.954
CLA	0.70a	0.72a	0.77a	0.69a	0.44b	0.35b	0.67a	0.55b	0.05	<.001	0.021	0.801
C20:0	0.14a	0.14a	0.16c	0.15ac	0.12b	0.11b	0.13	0.13	0.03	<.001	0.821	0.819
C20:1	0.096a	0.095a	0.107a	0.091a	0.072b	0.059b	0.080a	0.092b	0.004	<.0001	0.0080	0.9152

a, b, c, d – values in rows with different letters differ significantly ($P < 0.05$); M1, M2, M3, M4, M5, M6 – milk from different dairies; M – dairy; S – season

M × S – interaction between dairy and season; LA – linoleic acid; ALA – α-linolenic acid; CLA – conjugated linoleic acid

Table 2.
Fatty acid types and ratios depending on the dairy and the production season (% of total fatty acids)

Fatty acids	Milk from Małopolska (Poland)						Season		SEM	P-value		
	Milk from mountain regions				Milk from other regions							
	M1	M2	M3	M4	M5	M6	Summer	Winter		M	S	M × S
SFA	69.60a	68.64a	70.74ab	71.25b	71.96b	72.01b	70.64	70.84	0.48	<.001	0.533	0.431
UFA	30.36a	30.23a	29.22ab	28.71ab	28.02b	27.97b	29.32	28.77	0.36	<.001	0.060	0.614
MUFA	27.39a	27.28a	26.27ab	25.84b	25.61b	25.56b	26.51	26.08	0.28	<.001	0.063	0.560
PUFA	2.96a	2.93a	2.95a	2.85a	2.40b	2.40b	2.80	2.68	0.11	<.001	0.188	0.773
PUFA n-3	0.54a	0.57a	0.68a	0.61a	0.35b	0.28b	0.51	0.49	0.03	<.001	0.319	0.954
PUFA n-6	2.43	2.38	2.27	2.25	2.05	2.13	2.29	2.20	0.08	0.084	0.176	0.627
DFA[1]	40.59a	40.51a	39.14a	38.47ab	37.08b	36.38b	39.37a	37.87b	0.57	<.001	0.001	0.645
OFA[2]	59.37ac	58.36a	60.81ab	61.61bc	62.90b	63.59b	60.44a	61.74b	0.66	<.001	0.030	0.609
DFA/OFA	0.69a	0.70a	0.65ac	0.63ab	0.59bc	0.57b	0.65a	0.62b	0.01	<.001	0.003	0.678
UFA/SFA	0.44a	0.44a	0.41ab	0.40ab	0.39b	0.39b	0.42	0.41	0.007	<.001	0.116	0.550
n-6/n-3	5.01ad	4.28a	3.38b	3.80ab	5.97d	7.78c	5.08	5.05	0.31	<.001	0.913	0.620

a, b, c, d – values in rows with different letters differ significantly ($P < 0.05$). M1, M2, M3, M4, M5, M6 – milk from different dairies; M – dairy; S – season; M × S – interaction between dairy and season; SFA – saturated fatty acids, UFA – unsaturated fatty acids**,** MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids; SEM – standard error of the mean
[1]DFA (hypocholesterolemic fatty acids) = UFA + C18:0; [2]OFA (hypercholesterolemic fatty acids) = SFA – C18:0

DISCUSSION

The results of the study indicate a higher content of essential unsaturated fatty acids in drinking milk from cows from mountainous regions. Dairies located in these areas purchase milk from dairy farmers primarily keeping cows of native breeds with low or medium milk yields, adapted to extensive farming conditions. These breeds include Polish Red, Polish Black-and-White, and Polish Red-and-White (PFHBiPM, 2020). The diet of cattle of these breeds is based on roughage – mostly meadow grass and pasture forage in summer, and wilted grass silage, haylage, and hay in winter. The share of concentrated feed in the ration is small. In contrast, the raw milk purchased by dairies in other regions of Małopolska comes mainly from cows with higher milk yields, used in intensive rearing systems. These animals use pasture less often and are fed mainly on TMR or PMR diets. According to Bauman et al. (2003), this feeding system is less favourable in terms of UFA content, including CLA, than the traditional system that includes pasture grazing. The feed ration mainly consists of components such as maize silage, haylage, hay, and extracted meals or ground grains (Litwińczuk et al., 2014). The results of the present study confirm those reported by Radkowska (2013), who showed a positive effect of pasture management on the health properties of milk, as well as a particularly favourable UFA/SFA ratio, a higher content of MUFAs, PUFAs and DFAs. Studies by Lock and Garnsworthy (2003), Nałęcz-Tarwacka and Grodzki (2005), and Lipiński et al.

(2012) point to the season of production as one of the factors determining the level and proportion of fatty acids in cow milk fat. Pasture feeding increases the proportion of UFA, especially PUFAs and CLA. Cows fed on pasture produce more PUFAs (5.7 g/100 g FA) than those fed silage (2.8 g/100 g FA) (Elgersma et al., 2004; Khanal and Olson, 2004; Slots et al., 2009). The content of PUFAs is also higher in the milk of cows grazing in the mountains (2.18 g/100 g fat) than in the lowlands (0.81 g/100 g fat). Increased milk CLA and C18:1 content is influenced by plants of the families Compositae, Rosaceae and Plantaginaceae, which are found in greater quantities in natural meadow growth (Collomb et al., 2001). Pasture forage, which is a rich source of α-linolenic acid (C18:3, n-3), is the substrate used for the production of trans-vaccenic acid (TVA) and conjugated linoleic acid (CLA), which increase the activity of Δ9-desaturase, involved in the endogenous synthesis of CLA from trans 11 C18:1 acid in the tissues of the mammary gland (Lock and Garnsworthy, 2003). In contrast, the proportion of MUFAs decreases in the milk of cows fed silage (Whiting et al., 2004).

Research by Vetter and Wendlinger (2013) has shown that not only major fatty acids, but also various classes of bioactive fatty acids, such as furan fatty acids (F-acids), which are valuable antioxidants, contribute to the nutritional benefits of fats. They are found in the lipids of various food products, mainly in milk fat and butter, produced from milk from cows receiving larger amounts of grass feed. Wendlinger and Vetter (2014) found that F-acid levels in butter were higher in summer than in winter, and in both seasons samples of organic butter contained significantly higher levels of F-acids than conventional butter. According to Allison et al. (2020), drinking milk from cows grazing on permanent grassland has a healthier FA profile. This milk has a higher content of unique bioactive FAs (short-chain FAs, odd- and branched-chain FAs, vaccenic acid, and conjugated linoleic acids) than conventional milk and milk enriched with n-3 fatty acids, especially during the summer.

CONCLUSION

The study showed that drinking milk from cows of local breeds grazing in mountainous regions had a favourable health-promoting fatty acid profile. It contained more n-3 PUFAs, including α-linolenic acid C18:3 n-3, vaccenic acid C18:1 n-7, and CLA, than milk from cows from other regions of Małopolska. Milk from cows from mountainous regions also had significantly ($P < 0.05$) higher hypocholesterolemic fatty acid (DFA) content and DFA/OFA ratios. Higher levels of desirable DFAs and DFA/OFA ratios were found in drinking milk during the summer.

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