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Fatty acid profile and cholesterol content of the milk of cows raised in a low-input system, taking into account the production season

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Fatty acid profile and cholesterol content were determined in 127 milk samples collected from cows of three breeds (Polish Red, White-Backed and Simmental) raised on 13 farms in a low-input system. The reference group consisted of 53 milk samples collected from Polish Black-and-White Holstein-Friesians raised in an intensive technology system. The raw material produced on the low-input farms was found to have a higher proportion of unsaturated fatty acids, including mono- and polyunsaturated fatty acids, and lower cholesterol content than the milk obtained from the cows raised in an intensive system. It should be emphasized that in the spring/summer season the milk obtained on the low-input farms using a traditional feeding system contained nearly three times as much CLA – on average 0.73% (ranging from 0.54% in the White-Backed breed to as much as 1.17% in the Polish Red cows) – as the raw material from the intensive system. In the autumn/winter season (when the cows were fed conserved fodder) the differences CLA content in favour of the low-input system were only 0.16%. The production season differentiated the fatty acid profile and cholesterol content in the milk of the cows raised in the low-input system. The milk obtained in the spring/summer season had significantly higher proportions of PUFA and nearly twice as much CLA.

KEY WORDS: breeds of cows / milk / fatty acid profile / cholesterol content / low-input system

Milk and dairy products are one of the main elements of the daily human diet, as a source of high-value proteins, fat, minerals and vitamins. Milk fat is highly digestible (97-99%), which is linked to a high degree of fat dispersion, owing to which it can be absorbed without prior hydrolysis in the digestive tract. In comparison with other edible fats, milk fat contains over 60% saturated fatty acids (SFA), usually associated by the public with the threat of obesity, high cholesterol, and atherosclerosis. However, a unique feature of milk fat is the presence of short-chain saturated fatty acids, which are utilized entirely as a source of energy essential to organ function, so that they do not pose a risk of obesity [3, 5, 12, 16]. An important group of fatty acids is unsaturated acids, which have the highest content of bioactive components in the lipid fraction of milk. Many authors [5, 11, 16, 22] claim that consumption of milk and dairy products not only does not lead to increased incidence of cardiovascular disease or cancer, but may even reduce the risk of these diseases.

Commercial milk production takes place mainly on farms using intensive farming technologies. These require substantial financial inputs, but ensure that the dietary needs of cows are optimally met, thereby enabling maximum exploitation of their genetic potential [14]. In many regions, however, natural and economic conditions, such as the shape of the terrain, are not conducive to intensification of agricultural production, including intensive milk production. Therefore local breeds of cows are usually raised in these areas, such as Simmental, Polish Red, White-Backed, Pinzgauer, and Brown Swiss. These breeds are less productive, but valued by farmers for their longevity and resistance to disease and because they are easily impregnated [18]. Milk production usually takes place in a low-input system, with a traditional feeding system based mainly on feed from permanent grassland.

The aim of the study was to evaluate the fatty acid profile and cholesterol content of the milk of three breeds of cow (Polish Red, White-Backed and Simmental) raised on low-input farms, taking into account the season of production. The reference group was the milk of Polish Holstein-Friesian cows raised in an intensive system.

Material and methods

The material for the study consisted of 127 milk samples collected from cows of three breeds—White-Backed (54), Polish Red (37) and Simmental (36), kept on 13 low-input farms. The average herd size was 17.8 cows, with yield of 4,200 kg of milk per lactation. Milk production was mainly based on feed from permanent grassland, which covered on average 69.7% of the area of the farm. During the spring/summer season the diet of the cows was based on pasture forage, and during the autumn/winter season on haylage and hay, supplemented in both seasons with concentrate feed (cereal meals).

The reference group consisted of 53 milk samples collected from Polish Black-and-White Holstein-Friesian cows raised on one farm in an intensive milk production system. The average yield of the cows was 7,143 kg per lactation. The area of the farm was dominated by arable land (58.3%), on which the main crop was maize for silage. The animals were housed in a free-stall barn and fed year round in a TMR (total mixed ration) system. The TMR ration consisted of maize silage, haylage, hay, extraction meal and cereal meals.

The herds analysed were situated in south-eastern Poland. All of them were subject to use value assessment for dairy cattle and met the necessary requirements for milk production defined by Commission Regulation (EC) no. 1662/2006 of 6 November 2006, amending Regulation (EC) no. 853/2004 of the European Parliament and of the Council laying down specific hygiene rules for food of animal origin.

The milk samples were collected individually from each cow, from a complete evening milking procedure during control milking (AT4 method), twice a year, i.e. in the spring/summer season (May-August) and the autumn/winter season (November-March). The following were determined in each milk sample:

– somatic cell count (SCC), with a Somacount 150 apparatus (Bentley), to eliminate milk samples with SCC higher than 400,000/ml

– fatty acid profile, using a gas chromatograph (Varian GC 3900) with a flame ionization detector (FID) and a 100 metre CP 7420 capillary column. The following groups of acids were distinguished in the evaluation: saturated (SFA), including short- and medium-chain fatty acids (SFAsmc), i.e. acids from C4:0 to C14:0, and long-chain fatty acids (SFAlc) from C15:0 to C22:0; and unsaturated fatty acids (UFA), including monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA). The percentage content of the fatty acids was calculated using Star GC Workstation Version 5.5, based on the retention times of standard fatty acid methyl esters. The milk samples for these analyses were prepared according to AOAC standards [1, 2].

– cholesterol content, according to the method developed by the National Research Institute of Animal Production in Balice (with our own modifications), using a Varian Carry 300 spectrophotometer, at a wavelength of 570 nm [19]

Statistical analysis of the results was performed using StatSoft Inc. Statistica software ver. 6 (StatSoft Inc., 2003). Two-way analysis of variance (ANOVA) was used to determine the effect of the season and production system. Significance of differences between means was determined by an LSD (least significant differences) test at $p \leq 0.05$ and $p \leq 0.01$.

Results and discussion

From the point of view of health promotion, what is most significant for consumers of milk is the content of biologically active compounds (whey proteins, unsaturated fatty acids, minerals and vitamins). The data in the table show that the milk of the cows kept in the low-input system had higher content of unsaturated fatty acids (UFA; on average 30.98%), including monounsaturated fatty acids (MUFA; on average 27.46%) and polyunsaturated fatty acids (PUFA; on average 3.52%), as compared to the milk obtained in the intensive system (24.39; 22.85 and 2.55%, respectively). It should be emphasized that in the spring/summer season the milk obtained on low-input farms using a traditional feeding system contained nearly three times as much CLA (conjugated linoleic acid)—on average 0.73% (from 0.54% in the White-Backed breed to as much as 1.17% in the Polish Red cows), in comparison with the intensive system. In the autumn/winter season (when the cows received dry feed and silage), the differences in the content of CLA in favour of the low-input system were only 0.16 percentage points (p.p.). The low proportion of unsaturated fatty acids (including CLA) in the milk obtained from the cows raised in intensive technologies is probably linked to the use of the TRM feeding system. According to Bauman et al. [8], the feeds used in TMR have a lower concentration of unsaturated fatty acids (including CLA) in comparison with the traditional system. Similar results were obtained by Butler et al. [10], who claim that increasing the proportion of concentrate feed in the feed ration increases its energy density. This is conducive to higher productivity in cows, but also has a negative effect on the fatty acid composition of the milk, as it increases the content of SFA and decreases that of UFA. These tendencies have been confirmed by numerous authors [6, 9, 23].

Many authors [10, 13, 17, 20] indicate the production season as one of the factors determining the level and proportions of fatty acids in milk, which is a consequence of the quality of the feed used. Bargo et al. [4] showed that introducing green fodder into the TMR system (increasing PUFA in the diet) decreased the content of long-chain saturated fatty acids in the milk from 48.11 to 45.06 g/100 g of fatty acids. In the present study, milk produced during the spring/summer period on low-input farms raising local breeds of cows had higher content of PUFA (by 1.29 p.p.) and nearly three times more CLA than milk obtained on the large-scale farm. This was probably due to the fact that the animals were pastured. It should be emphasized that the highest proportion of these acids was noted in the milk of the Polish Red breed (4.76% PUFA; 1.17% CLA).

In a study by Żegarska et al. [24], the proportion of *cis*9*trans*11 C18:2 (CLA) ranged from 1.06% to 1.76% (on average 1.40%) in milk fat from the summer feeding period and from 0.29% to 0.61% (on average 0.40%) in milk fat from the winter period. In the present study, no seasonal differences were noted in the content of unsaturated fatty acids in the milk obtained on the large-scale farm (from Polish Holstein-Friesian cows raised in an intensive system). This was probably due to the uniform supply of nutrients year round in the TMR rations (Tab.).

Rutkowska et al. [21], however, who determined the fatty acid profile in the milk of cows fed in a TMR system, did find seasonal differences in the content of these acids. Milk samples from the autumn season had a significantly higher proportion of MUFA—29.43 g/100 g of fatty acids—as compared to the lowest content noted in the spring—24.40 g/100 g of fatty acids. The authors link this fact to variability in the quality of the feed used during storage. Feed from the autumn period (newly produced) had the highest content of unsaturated fatty acids. With storage time the quantity of these acids decreased.

The data in the table indicate that the milk produced in a low-input system had a more favourable SFA/UFA ratio: 2.19 during the spring/summer period and 2.38 during the autumn/winter period. For comparison, in the reference group the value for this indicator was 2.69 in the summer and 3.30 in the winter.

The milk of local breeds used in a low-input system contained less cholesterol than the milk of the Polish Holstein-Friesians used in an intensive system (Tab.). The mean cholesterol content in the milk from the low-input farms in the autumn/winter period was 16.36 mg/100 ml, which was as much as 5.43 mg/100 ml less (nearly a third) than in the milk produced in the intensive system. In the summer period these differences, i.e. for

Table

Proportions of fatty acids and cholesterol content in the milk of cows of each breed, taking into account the season of production ($\bar{x}$ ±Sd)

Breed	Production season	n	Fatty acids (%)							Ratios between acids			Cholesterol (mg/100 ml)
			SFA	SFAsmc	SFAlc	UFA	MUFA	PUFA	CLA	SFA/UFA	MUFA/SFA	PUFA/SFA	
White-Backed	autumn-winter	22	70.23 ±5.41	22.28^{a} ±3.60	47.95^{B} ±4.47	29.39 ±5.39	26.44 ±4.96	2.95^{a} ±0.59	0.47 ±0.24	2.50 ±0.63	0.384 ±0.105	0.043 ±0.011	17.64 ±5.56
	spring-summer	32	68.78 ±3.40	25.88^{b} ±5.97	42.90^{A} ±6.45	30.75 ±3.43	27.47 ±3.40	3.28^{b} ±0.46	0.54 ±0.13	2.28 ±0.39	0.402 ±0.067	0.048 ±0.008	20.17 ±4.64
Polish Red	autumn-winter	19	68.92 ±3.95	19.84 ±3.49	49.07^{B} ±3.25	30.75 ±3.99	27.80 ±3.64	2.95^{A} ±0.43	0.38^{A} ±0.08	2.29^{b} ±0.39	0.408 ±0.080	0.043^{A} ±0.008	15.69^{a} ±4.21
	spring-summer	18	67.12 ±2.35	21.93 ±3.52	45.18^{A} ±3.21	32.48 ±2.41	27.72 ±2.23	4.76^{B} ±0.85	1.17^{B} ±0.71	2.08^{a} ±0.24	0.414 ±0.046	0.071^{B} ±0.014	20.03^{b} ±7.91
Simmetal	autumn-winter	18	71.75 ±4.28	22.19 ±2.69	49.56^{B} ±4.35	30.53 ±1.90	27.13 ±1.86	3.43^{a} ±0.30	0.40^{a} ±0.09	2.36 ±0.19	0.379^{a} ±0.031	0.048^{a} ±0.004	15.51^{A} ±4.09
	spring-summer	18	68.77 ±4.00	22.68 ±3.25	46.09^{A} ±2.22	31.95 ±3.95	28.22 ±3.50	3.73^{b} ±0.64	0.63^{b} ±0.42	2.17 ±0.39	0.421^{b} ±0.078	0.056^{b} ±0.012	22.34^{B} ±8.06
Low-input system	autumn-winter	59	70.27^{B} ±4.85	21.47 ±3.05	48.86^{B} ±4.56	30.18 ±3.34	27.10 ±3.57	3.11^{A} ±0.48	0.42^{A} ±0.14	2.38^{b} ±0.41	0.391 ±0.72	0.044^{a} ±0.007	16.36^{A} ±5.11
	spring-summer	68	68.08^{A} ±3.97	23.50 ±3.64	44.72^{A} ±3.61	31.53 ±3.12	27.73 ±3.38	3.79^{B} ±0.59	0.73^{B} ±0.48	2.19^{a} ±0.35	0.414 ±0.59	0.056^{b} ±0.010	20.70^{B} ±7.23
Reference group	autumn-winter	25	76.38^{B} ±2.09	24.89^{B} ±2.42	51.49 ±3.07	23.35 ±2.10	20.76 ±2.15	2.59 ±0.28	0.26 ±0.05	3.30^{B} ±0.38	0.273^{A} ±0.035	0.034 ±0.003	21.79 ±3.97
	spring-summer	28	72.34^{A} ±3.30	21.12^{A} ±2.60	51.22 ±2.78	25.43 ±3.31	24.93 ±3.15	2.50 ±0.21	0.28 ±0.10	2.69^{A} ±0.46	0.347^{B} ±0.059	0.035 ±0.004	24.11 ±4.81

n – number of samples

a, b – differences between seasons significant at $p \leq 0.05$; A, B – differences between seasons significant at $p \leq 0.01$

milk produced in the low-input and intensive systems, were lower by half, at only 3.41 mg/100 ml (16.5%). Significantly higher cholesterol content in all four breeds evaluated was noted in the milk from the spring/summer period, and the differences for the Simmental and Polish Red breeds were statistically significant (at $p \leq 0.01$ and $p \leq 0.05$). This should probably be linked to the higher proportion of small fat globules in the milk from the summer season. This means that the membranes of the fat globules, where cholesterol is localized, have a larger surface area. These tendencies were confirmed in a study by Barłowska et al. [7], which showed positive correlations between cholesterol content and the proportion of small fat globules (r=0.27***). Similar results for cholesterol content in milk (22.71 mg/100 ml for the spring/summer and 18.69 mg/100 ml for the autumn/winter) were obtained by Kowal [15] in the milk of four breeds of cow fed in a total mixed rations system (TMR).

To sum up, the material produced on low-input farms had a higher proportion of unsaturated fatty acids, including mono- and polyunsaturated fatty acids, and lower content of cholesterol than the milk obtained from cows raised in an intensive system. The production season differentiated the fatty acid profile and cholesterol content in the milk of the cows in the low-input system. The milk obtained in the spring/summer contained significantly more PUFA acids and nearly twice as much CLA.

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