Fatty acids and composition of their important groups in milk fat of Czech Pied cattle

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ABSTRACT: In 2003, 2004 and 2005 milk fat composition was determined three times in 55 dairy cows of Czech Pied cattle housed in a byre with stanchions and fed under conditions usual on Czech production farms. Fatty acids were determined by a gas chromatographic method, 26 acids out of the total 37 acids observed in chromatograms were identified. The highest proportions were observed for palmitic acid (29.25 ± 2.98%), oleic acid (24.47 ± 3.27%), myristic acid (12.14 ± 1.80%) and stearic acid (8.91 ± 2.44%). The proportions of saturated, unsaturated and monounsaturated fatty acids were 64.71 ± 4.18, 31.96 ± 4.20 and 27.45 ± 3.42% of total acids, respectively. The total proportion of nutritionally undesirable lauric, myristic and palmitic acid was 45.26 ± 4.77%, while that of the desirable group of polyunsaturated fatty acids was 4.51 ± 1.09%. The observed relatively wide ranges of the individual groups of fatty acids indicate that it is possible to improve the milk fat composition in Czech Pied cows.

Keywords: Czech Pied cattle; milk fat; fatty acid proportion

A permanently growing attention is paid to the production of cow milk as a raw material with defined optimal composition and properties. Such an effort arises from increasing requirements for the quality of milk products. The position of milk products in the market is maintained and improved by innovations as the competition of traditional higher-fat milk products with products containing cheaper fats of plant origin has become keener.

Nutritionists also started to call for changes in milk composition. The former, commonly respected outstanding role of milk and milk products in human nutrition was somewhat impaired by data on the participation of saturated fatty acids, *trans*-unsaturated fatty acids and cholesterol in cardiovascular diseases (e.g. Welch et al., 1997; Precht and Molkentin, 2000; Playne et al., 2003; Parodi, 2004), despite of the frequently reported positive role of polyunsaturated fatty acids and of proved possibilities to increase their proportion in milk fat (e.g. Offer et al., 1999; Jensen, 2002; Lock and Bauman, 2004).

Thus, the endeavours to optimise the milk fat composition have been interesting for farmers, dairy technologists and consumers. The interest of technologists has persisted since the start of the industrial production of butter until now (Chouinard et al., 1998; Bobe et al., 2003; Chen et al., 2004). It can be supposed that farmers will be interested in the optimisation of milk fat composition if they are motivated in a similar manner like for the production of milk with improved quality parameters (Goddard, 2001).

Perdrix et al. (1996), Jahreis (2000) and Thomson et al. (2001) reported different methods of improving the milk fat composition. The application of current knowledge of cattle genetics and controlled nutrition of milking cows were termed by Goddard (2001) as the prevailing methods.

The fatty acid synthesis in ruminants is largely affected by nutrition. Bauman and Griinari (2003) reported that about one half of milk fatty acids is synthesised *de novo* and fatty acids with chain over 16 carbons are formed mainly from blood lipids.

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The proportion of the individual fatty acids is also affected by biohydrogenation in the rumen (Avila et al., 2000). Ashes et al. (1997) observed that the usual relation between saturated and unsaturated acids changed when cows were fed fats preserved against the undesirable biohydrogenation. Changes in the milk fat composition due to different feed rations and feed additives were therefore widely studied (e.g. Jenkins, 1999; Delbecchi et al., 2001; Martin et al., 2002; Whitlock et al., 2003).

The application of genetic knowledge for the optimisation of milk fat composition is possible on the basis of genetic variability and heritability of milk fat composition both between the breeds and within the breeds (Goddard, 2001).

The milk fat composition of all important breeds of dairy cattle has been studied frequently, mainly the inter-breed differences and responses of the different breeds to changes in feed rations (Beaulieu and Palmquist, 1995; DePeters et al., 1995; Bitman et al., 1996; Townsend et al., 1997; Lawless et al., 1999; Drackley et al., 2001; Malacarne et al., 2001; White et al., 2001).

Even though some partial data on the milk fat composition in Czech Pied cattle and its crossbred cows were published (Komprda et al., 2001, 2005; Pešek et al., 2005), no systematic study using numerous files of analytical data has been carried out yet. The aim of our work was therefore to provide more data, especially on the composition of milk fatty acids of the breed widely used in the Czech Republic.

MATERIAL AND METHODS

A design of milk sampling for the determination of fatty acids in milk fat reflects the current state of milk production on farms and of milk fat composition in Czech Pied cattle. Raw milk is processed in dairies for products for human consumption.

In May 2003, July 2004 and February 2005 milk was sampled from dairy cows fed three different feed rations (Table 1) during the regular testing of milk efficiency on a farm in Čejkovice-Dubné near České Budějovice. The selected cows of Czech Pied cattle were housed together in a byre with stanchions for 200 animals. The feed rations were calculated for the mean live weight of animals 600 kg.

The tested groups of cows (n = 55 in total) were put together for each sampling according to the lactation number and stage of lactation. The main characteristics are given in Table 2. Fat, protein and lactose contents were determined spectrophotometrically using a Milcoscan 4000 apparatus (Foss Electric).

The raw milk samples were immediately transported to the laboratory, freeze-dried and fat was extracted with petroleum ether. Fat was re-esteri-

Table 1. Main ingredients of feed rations and composition of production feed mixtures in the particular years

	2003	2004	2005
Ingredients (kg)			
Maize silage	21	4	19
Lucerne silage	10		
Grass silage		27	
Grass and broad bean silage			13
Barley draff		4	
Mashed oats			1
Hay			0.5
Production feed mixture (%, w/w)			
Barley	37	31	20
Maize	29	–	–
Wheat	20	27	20
Oats	–	–	12
Soybean meal	10	10	20
Rapeseed meal	–	28	25
Salt, minerals and vitamins	4	4	3

Table 2. Milk yields and main parameters of the milk composition of tested cows

	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}_{min}$	$\bar{x}_{max}$	RSD (%)[1]
Milk (kg/d)	18.64	5.66	6.60	36.80	30.37
Fat (%)	4.47	0.74	2.66	5.98	16.49
Protein (%)	3.41	0.32	2.79	4.42	9.41
Lactose (%)	4.94	0.15	4.50	5.30	3.03

[1]relative standard deviation

Table 3. Parameters of chromatographic analysis of fatty acids

Parameter	Value
Column	Omegawax 530, 30 m
Detector	FID
Temperature:	40°C for 3 min
–column	20°C/min up to 150°C
	2.5°C/min up to 240°C
–injector	250°C
–detector	250°C
Nitrogen flow	6 ml/min
Injection	1 µl

fied to methyl esters of fatty acids by heating the petroleum ether extract with a methanolic solution of potassium hydroxide. Methyl esters of fatty acids were determined by gas chromatography (GLC) using a Varian 3300 apparatus (Varian Techtron, Australia). Parameters of the chromatographic determination are given in Table 3.

The acids were identified using their standards (Supelco, USA). 26 acids out of the total 37 acids observed in chromatograms were identified. The proportions of the individual acids were calculated from the ratio of their peak area to the total area of all the observed acids.

RESULTS AND DISCUSSION

Mean contents of fatty acids determined in the milk fat samples during three consecutive years are given in Table 4. The results of fatty acid composition in milk fat of Czech Pied cows are similar to the fat composition of important dairy breeds (Holstein, Jersey, Brown Swiss) reported by Morales et al. (2000), Delbecchi et al. (2001) and Kelsey et al. (2003). Within the individual groups of fatty acids, acids present in the highest concentration are the same in all the mentioned breeds. Palmitic acid ($C_{16:0}$), myristic acid ($C_{14:0}$) and stearic acid ($C_{18:0}$) in the group of saturated fatty acids (SAFAs), oleic acid ($C_{18:1}$) and palmitoleic acid ($C_{16:1}$) among monounsaturated acids (MUFAs), linoleic acid ($C_{18:2n6}$) and α-linolenic acid ($C_{18:3n3}$) in the group of polyunsaturated fatty acids (PUFAs) were the acids occurring in the milk fat of Czech Pied cows in the highest concentrations (Table 4).

Significant differences in fatty acid composition in milk fat of different breeds were reported. Beaulieu and Palmquist (1995) found significantly higher proportions of caprylic ($C_{8:0}$), capric ($C_{10:0}$), lauric ($C_{12:0}$) and myristic acid ($C_{14:0}$), while the proportions of palmitic ($C_{16:0}$) and oleic acid ($C_{18:1}$) were lower in milk fat of Jersey cows compared with Holstein cows. Moreover, Drackley et al. (2001) reported significant differences between the same breeds also in proportions of butyric ($C_{4:0}$), myristoleic ($C_{14:1}$) and linolenic acid ($C_{18:3}$). Comparing eight-cow groups of Czech Pied and Holstein cows, significant differences in proportions of capric, stearic and oleic acid were observed in our previous study (Pešek et al., 2005).

Compared to the cited literature data for Holstein and Jersey cows, a lower proportion of palmitic acid (29.25%) and a higher proportion of oleic acid (24.47%) were observed in our group of 55 Czech Pied cows. Kelsey et al. (2003) reported a lower proportion particularly of myristic acid (8.15 and 8.53% for Holstein and Brown Swiss cows, respectively), while the mean level of 12.14% was found in our group.

However, to evaluate the inter-breed differences, further important factors affecting the milk fat composition have to be taken into consideration, namely nutrition, season, lactation number and stage of lactation (e.g. Jahreis, 2000; Komprda et al., 2001; Whitlock et al., 2003). The data collected in Table 4 can be accepted as characteristic of the milk fat composition of Czech Pied cattle as they represent results from 55 cows, three consecutive years and all the above-mentioned factors were included in our study.

Table 4. Fatty acid composition (% of the total 37 fatty acids, w/w) of milk fat of Czech Pied cows (2003–2005, n = 55)

	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}_{min}$	$\bar{x}_{max}$	RSD (%)
$C_{4:0}$	1.98	0.62	0.54	3.65	31.25
$C_{6:0}$	1.67	0.40	0.68	2.34	23.93
$C_{8:0}$	1.26	0.26	0.69	1.68	20.33
$C_{10:0}$	3.25	0.70	1.92	4.44	21.65
$C_{11:0}$	0.07	0.03	0.03	0.14	37.25
$C_{12:0}$	3.88	0.81	2.26	5.39	21.00
$C_{13:0}$	0.13	0.03	0.08	0.23	22.52
$C_{14:0}$	12.14	1.80	8.15	15.19	14.81
$C_{15:0}$	1.29	0.17	0.83	1.67	12.82
$C_{16:0}$	29.25	2.98	22.53	39.14	10.19
$C_{17:0}$	0.67	0.11	0.53	1.07	16.91
$C_{18:0}$	8.91	2.44	5.50	16.11	27.39
$C_{20:0}$	0.20	0.05	0.12	0.36	24.71
$C_{14:1}$	0.92	0.23	0.41	1.56	25.21
$C_{16:1}$	1.75	0.35	1.25	2.84	20.22
$C_{18:1}$	24.47	3.27	19.30	30.85	13.35
$C_{20:1}$	0.31	0.09	0.15	0.51	28.27
$C_{16:2n4}$	0.13	0.08	0.03	0.50	61.29
$C_{16:3n4}$	0.34	0.09	0.21	0.65	26.59
$C_{18:2n6}$	2.22	0.77	1.29	3.91	34.75
$C_{18:3n3}$	0.53	0.12	0.31	0.98	22.91
$C_{18:3n4}$	0.13	0.03	0.06	0.21	24.19
$C_{18:3n6}$	0.08	0.02	0.04	0.12	21.75
$C_{18:4n3}$	0.80	0.27	0.36	1.55	34.36
$C_{20:3n6}$	0.13	0.03	0.07	0.22	27.66
$C_{20:4n6}$	0.17	0.03	0.11	0.25	20.04
Unidentified	3.33	0.07	1.98	4.93	15.23
$C_{14:0}/C_{14:1}$	13.76	2.84	7.75	20.34	20.62
$C_{16:0}/C_{16:1}$	17.39	3.94	9.03	26.09	22.67
$C_{18:0}/C_{18:1}$	0.36	0.08	0.23	0.57	22.80
$C_{16:0}/C_{18:0}$	3.56	1.13	1.64	6.1	31.79

RSD = relative standard deviation

The mean contents of the main groups of determined fatty acids together with some relations between the groups are given in Table 5. The groups were evaluated mainly from two points of view: their effects on the health of milk and milk product consumers, and technological properties of milk fat. The usual interest in SAFAs, MUFAs and PUFAs was also aimed at further groups of fatty acids – volatile, short-, medium- and long-chain, *trans-* and n-3 ones (Offer et al., 1999; Hillbrick and Augustin, 2002; Schroeder et al., 2003; Lock and Bauman, 2004) and also at conjugated linoleic acids (CLAs).

In the group of SAFAs, lauric, myristic and palmitic acid was assessed as detrimental from the aspect of cardiovascular diseases (Jensen, 2002). These acids were designated in the following text and in Table 5 as "health-negative fatty acids" (HNFAs).

Table 5. Proportions (% of the total 37 fatty acids, w/w) of major groups of fatty acids in milk fat of Czech Pied cattle and relations between the groups (2003–2005, n = 55)

	$\bar{x}$	$s_{\bar{x}}$	$\bar{x}_{min}$	$\bar{x}_{max}$	RSD (%)
SAFA	64.71	4.18	57.71	71.67	6.45
USFA	31.96	4.20	25.00	38.89	13.15
MUFA	27.45	3.42	21.98	34.68	12.47
PUFA	4.51	1.09	2.86	6.73	24.08
$PUFA_{n3}$	1.32	0.36	0.78	2.23	27.27
$PUFA_{n6}$	2.59	0.78	1.55	4.26	30.24
VFA	8.17	1.78	3.96	11.05	21.73
SCFA	12.25	2.45	6.94	15.85	19.97
MCFA	46.49	4.11	36.60	55.30	8.84
LCFA	37.93	5.72	29.25	50.72	15.08
HNFA	45.26	4.77	35.39	54.31	10.55
$PUFA_{n6/n3}$	1.98	0.36	1.22	2.62	18.04
n3/PUFA	0.29	0.03	0.23	0.37	11.15
n6/PUFA	0.57	0.05	0.45	0.66	9.67
PUFA/MUFA	0.16	0.03	0.12	0.24	18.30
PUFA/USFA	0.14	0.02	0.11	0.19	15.65
PUFA/SAFA	0.07	0.02	0.04	0.11	29.32
MUFA/USFA	0.86	0.02	0.81	0.89	2.55
MUFA/SAFA	0.43	0.08	0.31	0.59	18.77
USFA/SAFA	0.50	0.10	0.34	0.67	19.51
SAFA/USFA	2.08	0.41	1.50	2.87	19.68
HNFA/SAFA	0.64	0.04	0.52	0.71	6.34

RSD (%) = relative standard deviation
SAFA = saturated fatty acids
USFA = unsaturated fatty acids
MUFA = monounsaturated fatty acids
PUFA = polyunsaturated fatty acids
VFA = volatile fatty acids ($C_{4:0}$ – $C_{10:0}$)
SCFA = short-chain fatty acids (C_4 – C_{13})
MCFA = middle-chain fatty acids (C_{14} – C_{17})
LCFA = long-chain fatty acids (C_{18} – C_{20})
HNFA = health-negative fatty acids ($C_{12:0}$ + $C_{14:0}$ + $C_{16:0}$)

Different values of relative standard deviations of the mean proportions of SAFAs, MUFAs, PUFAs and VFAs were determined: 6.45, 12.47, 24.08 and 21.73%, respectively (Table 5). The proportions of PUFAs and VFAs ranged widely, while those of MUFAs and mainly of SAFAs fluctuated in a relatively narrow range. The different values of relative standard deviations of the individual groups of fatty acids shown in Figures 1–6 indicate what groups can be affected by an optimisation process of the milk fat composition in Czech Pied cows.

According to Fearon (2001), the optimisation of milk fat composition and of its technological properties is possible by using special feed additives containing fats protected against their biohydrogenation in the rumen. Such a method is more feasible and expeditious than genetic procedures. Goddard (2001) considered the optimisation only by the selection of a breed to be insufficient, as no

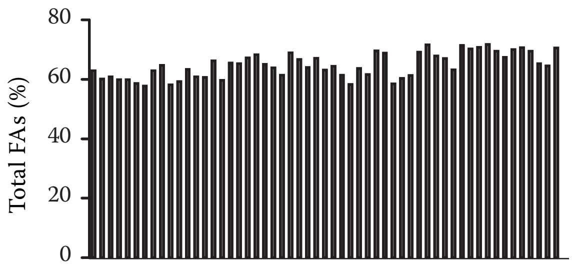

Figure 1. Variation of SAFAs proportion in the individual samples (n = 55)

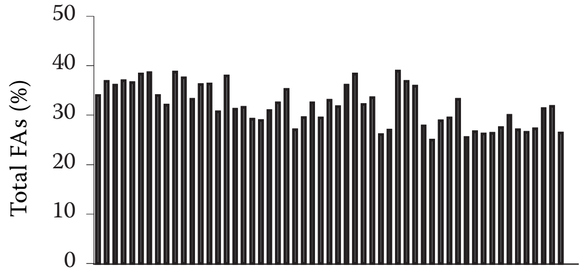

Figure 2. Variation of USFAs proportion in the individual samples (n = 55)

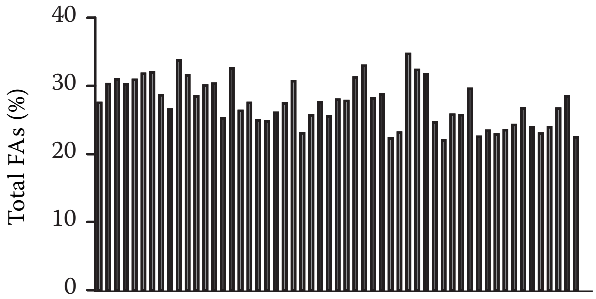

Figure 3. Variation of MUFAs proportion in the individual samples (n = 55)

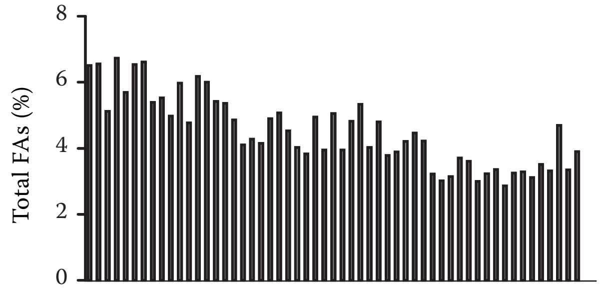

Figure 4. Variation of PUFAs proportion in the individual samples (n = 55)

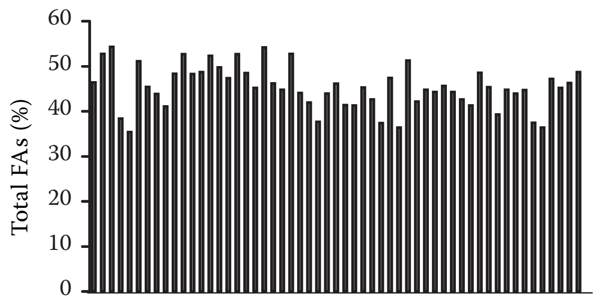

Figure 5. Variation of HNFAs proportion in the individual samples (n = 55)

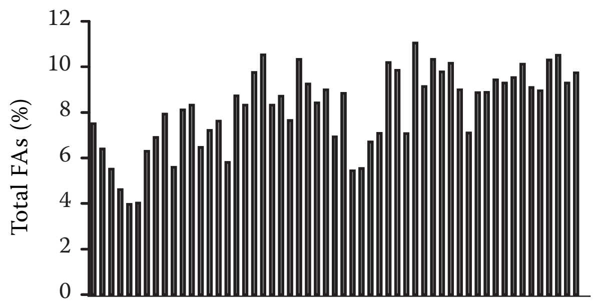

Figure 6. Variation of VFAs proportion in the individual samples (n = 55)

breed is likely to be best in each parameter and different breeds will be best suited for different products.

Two groups of fatty acids should be taken into consideration from the human nutrition aspect. The desirable group of PUFAs with the mean proportion 4.51 ± 1.09% and range 2.86–6.73% and the undesirable group of HNFAs with the values 45.26 ± 4.77 and 35.39–54.31%, respectively.

The relatively high relative standard deviations of the PUFA and HNFA groups, 24.08 and 10.55%, respectively, together with the high content and proportion of the nutritionally undesirable HNFA group call for the use of programs to improve the milk fat composition in Czech Pied cows. Data reported by Beaulieu and Palmquist (1995), Morales et al. (2000) and Drackley et al. (2001) showed the ranges of HNFA group 47.5–48.7% in milk fat of Holstein cows and 47.8–53.7% in Jersey cows. The mean proportion of Czech Pied cows 45.26% seems to be acceptable, however, we regard the improvement of milk fat composition as useful and promising. Published data of many research teams (e.g. Chouinard et al., 1998; Jenkins et al., 1999; AbuGhazaleh et al., 2002) proved a possibility of decreasing the proportion of the HNFA group considerably, by as much as 20% and even more within the group.

CONCLUSIONS

In 2003, 2004 and 2005 the milk fat composition was determined three times in 55 dairy cows of Czech Pied cattle housed in a byre with stanchions. Fatty acids were determined by a gas chromatographic method as methyl esters, 26 acids were identified out of the total 37 acids observed in chromatograms. Among the individual fatty acids, the highest proportions were observed for palmitic acid (29.25 ± 2.98%), oleic acid (24.47 ± 3.27%), myristic acid (12.14 ± 1.80%) and stearic acid (8.91 ± 2.44%). The proportions of SAFAs, USFAs and MUFAs were 64.71 ± 4.18, 31.96 ± 4.20 and 27.45 ± 3.42% of total acids, respectively. The total proportion of nutritionally undesirable lauric, myristic and palmitic acid was 45.26 ± 4.77%, while that of the desirable PUFA group was 4.51 ± 1.09%. The observed relatively wide ranges of the individual groups of fatty acids indicate that it is possible to improve the milk fat composition of Czech Pied cows.

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