Comparison of fatty acid composition in milk fat of Czech Pied cattle and Holstein cattle

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ABSTRACT: In May 2003 differences in milk fat composition in two main dairy breeds in the Czech Republic, Czech Pied cattle and Holstein cattle, were studied in two uniform groups, each containing eight cows. The groups were housed together and received the same daily diet. Fatty acids were determined in mean milk samples from the individual cows as their methyl esters using a gas chromatography procedure. The groups of the fatty acids, namely saturated (SAFA), monounsaturated (MUFA) and polyunsaturated (PUFA) ones, were examined together with the individual acids. The milk fat of Czech Pied cattle was found to contain significantly less SAFAs than the fat of Holstein cows (60.78 and 63.62% of total acids; $P < 0.05$). Determined mean MUFA contents (27.64 and 25.76%) and total levels (34.31 and 32.11%) of all the unsaturated acids (MUFAs and PUFAs) were insignificantly elevated in the milk fat of Czech Pied cattle. The contents of the most of the individual fatty acids did not differ considerably between the breeds. In Holstein cows, significantly higher contents ($P < 0.05$) of capric acid ($C_{10:0}$) and stearic acid ($C_{18:0}$) 3.30 and 4.45%, respectively, as compared with 2.69 and 2.61% for Czech Pied cows, were observed. The milk fat of Czech Pied cows had significantly higher contents of oleic acid ($C_{18:1}$) 23.60% ($P < 0.05$) and of an isomer of octadecatrienic acid ($C_{18:3n4}$) 0.16% ($P < 0.001$) as compared with 21.68 and 0.10%, respectively, in the fat of Holstein cows.

Keywords: cows; breeds; Czech Pied cattle; Holstein cattle; milk fat; fatty acids

Permanent attention of both dairy industry and nutritionists has been paid to milk fat composition. Fatty acids (FAs) are the most important components of lipids (Velíšek, 1999) and thus research dealing with milk fat has been focused mainly on fatty acid content and composition.

Milk fat can contain up to 400 different FAs. About seventy acids can be identified by usual analytical procedures (Collomb *et al.*, 2002a). However, a high number of them is present at very low and negligible amounts. Thus, usually only 20–30 FAs are determined in milk fat using a gas chromatography analytical procedure. Their contents range from several tenths to tens per cent out of total FA content.

However, current research results show that the evaluation of milk fat only according to the proportion of saturated (SAFAs), monounsaturated (MUFAs) and polyunsaturated (PUFAs) acids is not satisfactory. Mainly the results concerning biologically active isomers of conjugated linoleic acid (CLA) present in milk fat at elevated concentrations (Pariza *et al.*, 1999) and information on different nutritional properties of FAs (Legrand, 2002) require to study milk fat FA composition in greater detail. Under these circumstances, more detailed knowledge of factors affecting FA composition is necessary.

The most important factors are nutrition, season and breed. Appropriate supplements and corrections of feed rations can increase the proportion of unsaturated FAs and decrease the SAFA level at the same time (Jenkins, 1999; Komprda *et al.*, 2000; Delbecchi *et al.*, 2001; DePeters *et al.*, 2001). Collomb *et al.* (1999, 2002b) reported variable proportions of the individual groups of FAs due to dif-

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ferent botanical composition of pastures affected by the altitude.

Seasonal changes in milk fat FA composition were observed by Perdrix *et al.* (1996) and by Thomson *et al.* (2000). Seasonal changes reflected seasonal trends of the characteristics of milk fat for processing.

Numerous papers studied the effects of cow breeds. Differences in the milk fat composition in Holstein and Jersey breeds were investigated by Beaulieu and Palmquist (1995) and they were proved by Morales *et al.* (2000), Drackley *et al.* (2001) and by White *et al.* (2001). Similarly like in the cited papers, a significantly lower content of oleic acid was determined in milk fat of Jersey cows as compared with Black Pied Lowland cattle (Townsend *et al.*, 1997).

The comparison of milk fat composition in indigenous and imported breeds was also published. Malacarne *et al.* (2001) reported differences in FA contents of four cattle breeds in the cheese-producing region Parmigiano-Reggiano. Differences in the content of myristic, palmitic and myristoleic acids were also proved by Secchiari *et al.* (2003). Interbreed differences in the FA composition of milk fat from Black Pied breeds and Jersey cows were studied by Cecchi *et al.* (2003). Numerous papers deal with differences in the milk fat FA composition of indigenous and imported breeds and their crossbreds in Eastern and Southern Europe (Makarov and Khramtsová, 1994; Peichevski *et al.*, 1998; Sazhin and Katmakov, 1998; Zegarska *et al.*, 2001; Sterna and Jemeljanov, 2003).

However, limited information is available on the milk fat composition of two main dairy breeds (Czech Pied cattle and Holstein cattle) kept in the Czech Republic.

The aim of our study was to determine differences in milk fat composition in two main dairy breeds in the Czech Republic, Czech Pied cattle and Holstein cattle.

MATERIAL AND METHODS

Raw milk intended for human nutrition was sampled under the conditions typical of the current situation in Czech farming practice. Milk was sampled once from the individual cows during the regular testing of milk efficiency on a farm in Čejkovice-Dubné near České Budějovice in May 2003. Dairy cows of both tested breeds, Czech Pied cattle and Holstein cattle, were housed together in a byre with stanchions for 200 animals. The cows were fed a ration calculated for the mean live weight of 600 kg, consisting of 21 kg maize silage and 10 kg lucerne silage. An additional production feed mixture contained 37, 29, 20 and 10% (w/w) of feeding barley, maize, wheat and extracted soy meal, respectively, and 1, 1 and 2% of feeding salt, limestone and mineral and vitamin supplements, respectively. A group of eight dairy cows of either of the tested breeds was selected. Age and lactation number were uniform in both groups. Data on mean daily milk yield and milk composition are given in Table 1. Contents of fat, protein and lactose were determined spectrophotometrically, using a Milcoscan 4000 apparatus (Foss Electric).

In total, 16 samples of raw milk were immediately transported to the laboratory. Fat was isolated using an extraction procedure with petroleum ether according to Röse-Gottlieb (Cvak *et al.*, 1992). Fatty acids were determined by gas chromatography (GLC) using a Varian 3300 apparatus (Varian Techtron, Australia). The acids were re-esterified to methyl esters by boiling the petroleum ether solution of isolated fat with potassium hydroxide dissolved in methanol. Parameters of chromatographic analysis are given in Table 2. The acids were identified using their standards (Supelco, USA). 26 acids out of total 34 acids observed in the chromatograms were identified. The proportions of the individual acids were calculated from

Table 1. Yield and main parameters of milk composition of Czech Pied and Holstein cows

	Czech Pied cattle				Holstein cattle			
	$\bar{x}$	$s_{\bar{x}}$	min.	max.	$\bar{x}$	$s_{\bar{x}}$	min.	max.
Milk yield (kg/d)	18.46	4.06	13.0	24.7	24.54	4.92	18.1	34.1
Fat (%)	4.59	0.90	2.9	5.28	4.19	0.98	3.18	5.66
Protein (%)	3.42	0.14	3.18	3.55	3.13	0.31	2.6	3.46
Lactose (%)	4.94	0.18	4.6	5.1	4.86	0.24	4.5	5.3

Table 2. Parameters of chromatographic analysis of fatty acids

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

the ratio of their peak area to the total area of all the observed acids.

The results were statistically tested by *t*-test of significance of differences between means using Microsoft Excel program.

RESULTS AND DISCUSSION

The results of milk fat composition and elementary statistical data on the groups of SAFAs, MUFAs and PUFAs are given in Table 3. Evaluating the differences between these traditional groups of FAs, the milk fat composition of both breeds did not range to such an extent as the milk fat composition of grazing cows and cows fed a winter feed ration (Thomson *et al*., 2000; White *et al*., 2001; Agabriel *et al*., 2001) or following the supplementation of feeds with some components – e.g. canola oil (DePeters *et al*., 2001; Delbecchi *et al*., 2001).

We observed the greatest differences in milk fat composition between both breeds in the group of SAFAs (63.62 and 60.78% of total determined acids in Holstein and Czech Pied cows, respectively; $P < 0.05$). The lowest, insignificant differences were in the group of PUFAs (6.35 versus 6.67%). Somewhat larger, also insignificant differences were found out in the group of MUFAs, with a higher level in the fat of Czech Pied cows (27.64 versus 25.76%). Similar situation (34.31 versus 32.11%) was observed in the total content of unsaturated FAs (USFAs). A lower proportion of SAFAs in milk fat seems to be favourable for the human health because of their negative role in arteriosclerosis (Pfeuffer and Schrezenmeir, 2000).

Data on the individual groups of FAs similar to our results were reported in the milk fat of Black Pied Lowland cows by Thomson *et al.* (2000), Malacarne *et al.* (2001) and Cardak *et al.* (2003). A somewhat higher USFA proportion (36.4–40.0%) was observed in the same breed by Makarov and Khramtsova (1994) and Peichevski *et al.* (1998) while Jenkins (1999), Podkowka *et al.* (1999) and White *et al*. (2001) determined lower levels (26.3–28.1%). After feed supplementation with fish and soya oils AbuGhazaleh *et al*. (2002) observed in the milk fat of Holstein cows SAFA proportions 61.59 versus 63.06% and USFA proportions 27.40 versus 31.64%. The USFA proportion of 36.38–40.01% was reported in the milk fat of crossbred cows of Black Pied cattle with different proportions of Holstein cattle (Makarov and Khramtsova, 1994).

Within the group of SAFAs, palmitic acid ($C_{16:0}$) and myristic acid ($C_{14:0}$) accounted for the highest proportions in the milk fat of both breeds with mean values about 33 and 12.7%, respectively. Similar results were reported by Niemann-Sorensen and Tribe (1988) and Jensen (2002). However, we determined a lower proportion of stearic acid ($C_{18:0}$) compared to literature data. Its proportion ranged between 1.29 and 3.79% in the individual Czech Pied cows. The highest level 7.98% was determined in the milk fat of a Holstein cow. An elevated proportion of stearic acid in the milk fat of Holstein cows was reported by Morales *et al.* (2000) and by Drackley *et al.* (2001). Delbecchi *et al.* (2001) and White *et al.* (2001) even determined a higher proportion of stearic acid than that of myristic acid in the same breed. The differences can be partially explained by different feed rations.

Our mean proportion of butyric acid ($C_{4:0}$), similar in both breeds (1.41 and 1.44%), is lower in comparison with literature data (Morales *et al*., 2000; Drackley *et al*., 2001; Komprda *et al*., 2000, 2001).

Statistically significant differences in the proportions of individual saturated acids between both breeds were determined only for capric acid ($C_{10:0}$) (2.69 and 3.30% for Czech Pied and Holstein cows, respectively; $P < 0.05$) and similarly for stearic acid 2.61 and 4.45% ($P < 0.05$). Significant differences in the capric acid proportion between Holstein and Jersey cows were reported by Beaulieu and Palmquist (1995), Drackley *et al.* (2001) and by White *et al.* (2001). Morales *et al.* (2000) proved the effect of breed also for the stearic acid proportion. White *et al.* (2001), Drackley *et al.* (2001)

Table 3. Fatty acid composition (% out of total 34 studied fatty acids, w/w) of the milk fat of Czech Pied and Holstein cows

	Czech Pied cows				Holstein cows				$P_{crit.}$
	$\bar{x}$	$s_{\bar{x}}$	min.	max.	$\bar{x}$	$s_{\bar{x}}$	min.	max.	
$C_{4:0}$	1.41	0.69	0.62	2.16	1.44	0.75	0.04	2.23	0.9223
$C_{6:0}$	1.27	0.39	0.79	1.73	1.50	0.70	0.24	1.83	0.3372
$C_{8:0}$	1.02	0.17	0.81	1.26	1.26	0.52	0.50	1.50	0.0921
$C_{10:0}$	2.69	0.28	2.34	3.09	3.30	1.27	2.15	4.21	0.0334
$C_{11:0}$	0.25	0.05	0.18	0.32	0.30	0.13	0.15	0.38	0.1721
$C_{12:0}$	3.54	0.31	3.07	3.95	4.00	1.48	3.02	5.05	0.1033
$C_{13:0}$	0.13	0.02	0.11	0.15	0.14	0.05	0.10	0.18	0.7588
$C_{14:0}$	12.81	0.84	11.59	14.16	12.55	4.29	11.26	13.79	0.5866
$C_{15:0}$	1.59	0.16	1.43	1.92	1.47	0.52	1.27	1.68	0.1566
$C_{16:0}$	33.19	1.85	29.10	35.03	32.99	11.33	30.68	39.78	0.8752
$C_{18:0}$	2.61	0.82	1.29	3.79	4.45	2.26	2.59	7.98	0.0209
$C_{20:0}$	0.25	0.10	0.14	0.39	0.22	0.09	0.16	0.36	0.4875
$C_{14:1}$	1.08	0.27	0.76	1.46	1.06	0.42	0.72	1.40	0.9208
$C_{15:1}$	0.44	0.08	0.33	0.58	0.38	0.13	0.33	0.44	0.0705
$C_{16:1}$	2.04	0.29	1.69	2.52	2.20	0.83	1.67	2.75	0.3983
$C_{18:1}$	23.60	1.71	21.10	25.54	21.68	7.40	18.72	23.91	0.0408
$C_{20:1}$	0.48	0.05	0.42	0.58	0.43	0.18	0.27	0.57	0.3765
$C_{16:2n4}$	0.70	0.08	0.55	0.79	0.77	0.29	0.62	1.04	0.2599
$C_{16:3n4}$	0.33	0.02	0.30	0.36	0.36	0.14	0.29	0.53	0.3868
$C_{18:2n6}$	3.92	0.48	3.04	4.34	3.64	1.38	2.71	5.07	0.3576
$C_{18:3n3}$	0.78	0.16	0.60	1.14	0.72	0.27	0.56	0.95	0.4400
$C_{18:3n4}$	0.16	0.01	0.15	0.19	0.10	0.05	0.06	0.16	0.0003
$C_{18:3n6}$	0.34	0.03	0.31	0.39	0.31	0.11	0.25	0.37	0.0984
$C_{20:2}$	0.10	0.06	0.03	0.18	0.13	0.11	0.05	0.38	0.4952
$C_{20:3n6}$	0.14	0.02	0.11	0.17	0.13	0.06	0.07	0.22	0.4254
$C_{20:4n6}$	0.19	0.02	0.16	0.22	0.20	0.09	0.14	0.29	0.6182
SAFAs[1]	60.78	2.04	57.78	63.52	63.62	21.34	60.28	66.40	0.0279
MUFAs[2]	27.64	1.58	25.01	29.19	25.76	8.81	22.76	28.65	0.0618
PUFAs[3]	6.67	0.56	5.72	7.53	6.35	2.30	5.09	8.15	0.4362
USFAs[4]	34.31	1.78	31.88	36.70	32.11	2.45	29.13	35.43	0.0605

[1]saturated fatty acids, [2]monounsaturated fatty acids, [3]polyunsaturated fatty acids, [4]total unsaturated fatty acids

and Morales *et al.* (2000) reported significant interbreed differences for proportions of SAFAs $C_{4:0}$ to $C_{14:0}$. Significant differences between Black Pied Lowland cattle and Polish Red cattle were observed by Zegarska *et al.* (2001). The proportion of long-chain SAFAs was higher in Black Pied Lowland cows. Their results are similar to our observations. The effect of breed on the palmitic acid proportion in milk fat was also proved by Lawless *et al.* (1999), who compared Montbéliard, Normande and Holstein cattle, and by Malacarne *et al.* (2001) in four breeds from the cheese-producing region Parmigiano-Reggiano.

Within USFAs, oleic acid ($C_{18:1}$) showed the highest respective proportions 23.60 and 21.68% in the milk fat of Czech Pied and Holstein cows ($P < 0.05$). Statistically significant differences in the proportion of oleic acid between Holstein and Jersey cows were reported by Beaulieu and Palmquist (1995), Townsend *et al.* (1997), Drackley *et al.* (2001) and White *et al.* (2001). The effect of breed on the oleic acid proportion was also proved by Malacarne *et al.* (2001).

Mean proportions of linoleic acid ($C_{18:2n6}$) 3.92 and 3.64% for Czech Pied and Holstein cows, respectively, did not differ significantly and are comparable with literature data (e.g. Morales *et al.*, 2000; Drackley *et al.*, 2001).

The proportion of nutritionally valued α-linolenic acid ($C_{18:3n3}$) in both tested breeds ranged between 0.56 and 1.14% in the individual cows. Mean values were 0.78 and 0.72% for Czech Pied and Holstein cows, respectively, the difference being insignificant. A lower proportion of α-linolenic acid in the milk fat of Holstein cows was observed both by Drackley *et al.* (2001) (0.36–0.50 %) and by Precht and Molkentin (1999) (0.42–0.61%) while Avila *et al.* (2000) and Delbecchi *et al.* (2001) reported an elevated proportion 0.76–1.34%. Komprda *et al.* (2000) determined increased levels of α-linolenic acid (1.0–1.3%) in the milk fat of crossbreds of Czech Pied × Ayrshire × Red Holstein cattle. The proportion was affected by changes in the composition of supplemental meals.

A significant interbreed difference ($P < 0.001$) was observed in $C_{18:3n4}$ isomer of linolenic acid (0.16 and 0.10% for Czech Pied and Holstein cows, respectively).

CONCLUSIONS

Interbreed differences in the milk fat composition were observed between the groups of dairy cows of Czech Pied and Holstein cattle. The cows received the same feeds and were housed under the same conditions. The proportion of SAFAs in the total content of 34 studied fatty acids was significantly ($P < 0.05$) lower in the milk fat of Czech Pied cows (60.78%) than in the fat of Holstein cows (63.62%). Insignificant differences were observed in the proportion of USFAs (34.31 versus 32.11% for Czech Pied and Holstein cows, respectively), MUFAs (27.64 versus 25.67%) and PUFAs (6.67 versus 6.35%). The composition of milk fat was relatively similar in both breeds. In the milk fat of Holstein cows, significantly higher proportions ($P < 0.05$) of capric acid (3.30 versus 2.69%) and of stearic acid (4.45 versus 2.61%) were determined. In opposite, the milk fat of Czech Pied cows had a significantly higher proportion of oleic acid (23.6 and 21.68%; $P < 0.05$) and of $C_{18:3n4}$ isomer of octadecatrienic acid (0.16 and 0.10%; $P < 0.001$).

REFERENCES

AbuGhazaleh A.A., Schingoethe D.J., Hippen A.R., Kalscheur K.F., Whitlock L.A. (2002): Fatty acid profiles of milk and rumen digesta from cows fed fish oil, extruded soybeans or their blend. J. Dairy Sci., *85*, 2266–2276.

Agabriel C., Coulon J.B., Journal C., Rancourt B. de (2001): Composition chimique du lait et systèmes de production dans les exploitations du Massif central. Prod. Anim., *14*, 119–128.

Avila C.D., DePeters E.J., Perez-Monti H., Taylor S.J., Zinn R.A. (2000): Influences of saturation ratio of supplemental dietary fat on digestion and milk yield in dairy cows. J. Dairy Sci., *83*, 1505–1519.

Beaulieu A.D., Palmquist D.L. (1995): Differential effects of high-fat diets on fatty-acid composition in milk of Jersey and Holstein cows. J. Dairy Sci., *78*, 1336–1344.

Cardak A.D., Yetismeyen A., Bruckner H. (2003): Quantitative comparison of camel, goat and cow milk fatty acids. Milchwissenschaft, *58*, 34–36.

Cecchi F., Martini M., Scolozzi C., Leotta R., Verita P., Summer A. (2003): Milk fat globules in different dairy cattle breeds. Part II: Relationship to fatty acid composition. Ital. J. Anim. Sci., *2*, 269–271.

Collomb M., Butikofer U., Spahni M., Jeangros B., Bosset J.O. (1999): Composition en acides gras et en glycerides de la matière grasse du lait de vache en zones de montagne et de plaine. Sci. Aliments, *19*, 97–110.

Collomb M., Eyer H., Sieber R. (2002a): Chemische Struktur und Fettsäureverteilung des Milchfettes. Agrarforschung, *9*, 240–245.

Collomb M., Butikofer U., Sieber R., Jeangros B., Bosset J.O. (2002b): Correlation between fatty acids in cow's milk fat produced in the Lowlands, Mountains and Highlands of Switzerland and botanical composition of the fodder. Int. Dairy J., *12*, 661–666.

Cvak Z., Peterková L., Černá E. (1992): Chemické a fyzikálně-chemické metody v kontrole jakosti mléka a mlékárenských výrobků. 1. vyd. Praha, VÚPP – Středisko potravinářských informací. 221 s. ISBN 80-85120-36-4.
Delbecchi L., Ahnadi C.E., Kenelly J.J., Lacasse P. (2001): Milk fatty acid composition and mammary lipid metabolism in Holstein cows fed protected or unprotected canola seeds. J. Dairy Sci., *84*, 1375–1381.
DePeters E.J., German J.B., Taylor S.J., Essex S.T., Perez-Monti H. (2001): Fatty acid and triglyceride composition of milk fat from lactating Holstein cows in response to supplemental canola oil. J. Dairy Sci., *84*, 929–936.
Drackley J.K., Beaulieu A.D., Elliott J.P. (2001): Responses of milk fat composition to dietary fat or nonstructural carbohydrates in Holstein and Jersey cows. J. Dairy Sci., *84*, 1231–1237.
Jenkins T.C. (1999): Lactation performance and fatty acid composition of milk from Holstein cows fed 0 to 5% oleamide. J. Dairy Sci., *82*, 1525–1531.
Jensen R.G. (2002): The composition of bovine milk lipids: January 1995 to December 2000. J. Dairy Sci., *85*, 295–350.
Komprda T., Dvořák R., Suchý P., Fialová M., Šustová K. (2000): Effect of heat-treated rapeseed cakes in dairy cow diet on yield, composition and fatty acid pattern of milk. Czech J. Anim. Sci., *45*, 325–332.
Komprda T., Šustová K., Dvořák R., Tieffová P., Poul J. (2001): Changes fatty acid pattern, composition and technological parameters of milk in dairy cows fed heat-treated rapeseed cakes in the first stage of lactation. Czech J. Anim. Sci., *46*, 231–239.
Lawless F., Stanton C., L'Escop P., Devery R., Dillon P., Murphy J.J. (1999): Influence of breed on bovine milk cis-9, trans-11-conjugated linoleic acid content. Livest. Prod. Sci., *62*, 43–49.
Legrand P. (2002): Recent knowledge on saturated fatty acids: A better understanding. Sci. Aliments, *22*, 351–354.
Makarov V.M., Khramtsová E.N. (1994): The composition and technological quality of milk from Black Pied cows of different genetic groups. Nauchno ekhnicheskii Byulleten, Ukrainskii Institut Zhivotnovodstva, *63*, 53–57.
Malacarne M., Summer A., Formaggioni P., Franceschi P., Mariani P. (2001): Composizione in acidi grassi del grasso del latte di quattro razze bovine allevate nella zona di produzione del Parmigiano-Reggiano. Annali della Facolta di Medicina Veterinaria, Universita di Parma, *21*, 249–259.
Morales M.S. Palmquist D.L., Weiss W.P. (2000): Milk fat composition of Holstein and Jersey cows with control or depleted copper status and fed whole soyabeans or tallow. J. Dairy Sci., *83*, 2112–2119.
Niemann-Sørensen A., Tribe D.A. (1988): World Animal Science. 3. Meat Science, Milk Science and Technology. Elsevier Science Publishers, Amsterdam. 458 pp.
Pariza M.W. (1999): The biological activities of conjugated linoleic acid. In: Yurawecz M.P., Mossoba M.M., Kramer J.K.G., Pariza M.W., Nelson G.J.: Advances in Conjugated Linoleic Acid Research. Vol. 1. AOCS Press, Champaign. 12–20.
Perdrix M.F., Sutter F., Wenk C. (1996): Facteurs de variation de la composition en acides gras de la matière grasse du lait de vache. Rev. Suisse Agric., *28*, 71–76.
Pfeuffer M., Schrezenmeir J. (2000): Bioactive substances in milk with properties decreasing risk of cardiovascular diseases. Brit. J. Nutr., *84*, 155–159.
Peichevski I., Iliev T., Mikhailova G. (1998): Fatty acid and amino acid composition of milk from Black Pied cows. Zhivotnov. Nauki, *2*, 68–71.
Podkowka Z., Podkowka L., Čermák B., Podkowka W. (1999): Wplyw zywienia krow systemem PMR na zawartość bialka, tluszczu i kwasow tluszczowych w mleku. Ann. Warsaw Agric. Univ. Anim. Sci., No. 36, 15–24.
Precht D., Molkentin J. (2000): Trans unsaturated fatty acids in bovine milk fat and dairy products. Eur. J. Lipid Sci. Technol., *102*, 635–340.
Sazhin S.I., Katmakov P.S. (1998): The productivity and physicochemical composition and technological properties of milk from cows of various genotypes. Russ. Agric. Sci., *1*, 47–53.
Secchiari P., Mele M., Serra A., Buccioni A., Paoletti F., Antongiovanni M., Summer A. (2003): Effect of breed, parity and stage of lactation on milk conjugated linoleic acid content in Italian Friesian and Reggiana cows. Ital. J. Anim. Sci., *2*, 269–271.
Sterna V., Jemeljanov A. (2003): Comparison of fatty acids and cholesterol content in the milk of Latvian cows. Veter. Zootechn., *22*, 95–98.
Thomson N.A., Poel W. van der, Peterson S.W. (2000): Seasonal variation of the fatty acid composition of milk fat from Friesian cows grazing pasture. In: Proceedings of the New Zealand Society of Animal Production, Hamilton, New Zealand, *60*, 314–317.
Townsend S.J., Siebert B.D., Pitchford W.S. (1997): Variation in milk fat content and fatty acid composition of Jersey and Friesian cattle. In: Proceedings of the Twelfth Conference, Breeding responding to client needs, Dubbo, Australia, Part 1, 283–291.
Velíšek J. (1999): Chemie potravin 1. 1. vyd. OSSIS, Tábor. 352 s.
White S.L., Bertrand J.A., Wade M.R., Washburn S.P., Green J.T., Jr., Jenkins T.C. (2001): Comparison of fatty acid content of milk from Jersey and Holstein cows

consuming pasture or total mixed ration. J. Dairy Sci., *84*, 2295–2301.

Zegarska Z., Jaworski J., Paszczyk B., Charkiewicz J., Borejszo Z. (2001): Fatty acid composition with emphasis on trans C18:1 isomers of milk fat from Lowland and Black and White and Polish Red cows. Pol. J. Food Nutr. Sci., 10/51, 41–44.

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