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THE CHANGES OF FATTY ACIDS COMPOSITION IN BEEF OF CHAROLAISE BULLS SLAUGHTERED AT DIFFERENT WEIGHT

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Abstract

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The aim of this work was to evaluate a slaughter weight influence (500–580; 581–640; 641–700 kg) of Charolaise bulls on intramuscular fat content and fatty acid profile in *musculus longissimus thoracis (MLT)*. The beef samples from 144 bulls were used to be evaluated. Statistically evidential ($P < 0.05$) differences in the intramuscular fat proportions (1.14 < 1.54 < 1.76%) in MLT samples were proved at all the weight categories of bulls. The highest average proportional ratio was determined in palmitic acid (C16:0), that ranged from 23.75% in bulls at 500–580 kg weight category to 24.79 % at 641–700 kg weight group. The lowest ratio of MUFA was in eicosapentaeonic acid (C20:1), its content ranged from 0.36% in the third weight group to 0.53% in 500–580 kg weight group. The highest MUFA ratio was in oleic acid (C18:1) at amount of 39.64% with difference ± 2.932%. The oleic acid ratio in beef rose up linearly according to the higher slaughtering weight ($P < 0.01$). Positive relation was proved between a slaughter weight and C18:3 a C22:5 PUFA content. The decrease of eicosapentaeonic and eicosadienoic acid was negative due to the essentiality for human health.

bull, charolaise, beef, fatty acid, intramuscular fat

The current problem of all the food producers is to guarantee the food quality and safety. Nowadays a consumer does not just want the information about the total protein and fat content of a particular foodstuff but also it is necessary to bring up the proportions of the other components like the number of amino acids, specifically fatty acids that are contained in a certain product. Fat composition, exactly the proportion of each long-chain fatty acid is very often talked over owing to the nutritional importance for people. Unlike plants people can not make polyenic fatty acids n-3 and n-6 although they are essential for life, so they have to be supplied by diet (ŠUBRT, 2006). SERRANO *et al.* (2005) evaluated the fatty acid composition of a beef steak. The authors' present proportions 504.9 mg.100g^{-1} of saturated fatty acid and proportions 263 mg.100g^{1} of unsaturated fatty acid, the ratios of the most important acid n-3 was 23.40 mg.100g^{-1}. WEGLARZ *et al.* (1999) found significant difference in intramuscular fat content and most of MUFA and PUFA in beef samples from Holstein–Italian breed crosses. MOJTO *et al.* (1996) compared the individual fatty acid spectrum in *musculus longissimus thoracis* and *m. semimebranosus* of Czech Black Pied Lowland cows. The significant difference between the muscles ($P < 0.01$) was found at palmitic acid content (1.39%, resp. 47.45%), linolic acid content (1.24%, resp. 0.43%) and arachidonic acid content (4.11%, resp. 0.86%). The total saturated fatty acid content was 49.86 % and 47.45%. BARTOŇ *et al.* (2004) contrasted fatty acid composition in *musculus longissimus lumborum et thoracis* within beef samples of Aberdeen Angus, Hereford, Charolaise and Simmental bulls. The animals were fed by the same feeding rate based on corn silage, lucerne silage, lucerne hay and a concentrate mixture (38% of a dry matter). The fattening was terminated at slaughtering weight of 550 kg (in a small body type of bulls) and 630 kg in Charolaise and Simmental bulls. The results confirm the conclusion that fatty acid composition in a muscle is up to a certain level influenced by the grade of fattiness and particularly by intramuscular fatty acid content. However there was not found any excessive significant difference in intramuscular fat content among the breeds, it demonstrated the effect on higher fatty acid content in muscle of Charolaise and Simmental. The increasing fatty acid content was caused by PUFA n-6 ratio, not n-3 that is more important for human health. ALDAI *et al.* (2006) compared the difference in carcass and beef quality between the breeds Asturiana de los Valles and Asturiana de la Montana which is bred extensively, both are from Spain. High number of statistically important difference ($P < 0.05$) was proved at a single fatty acid proportion. PUFA amount was higher by 67 mg at extensive breed (339 $mg.100g^{-1}$) and more than twice more of CLA (5.29 $mg.100g^{-1}$). RAES *et al.* (2003) compared the beef quality in *musculus longissimus lumborum a semimembranosus* of Belgian Blue and Limousine. The meat samples were vacuum packaged and stored at 4 °C for 14 days. PUFA proportion in MLL of both breeds was the same (195 $mg.100g^{-1}$). There was higher quantity of fatty acid n-6 by 40 $mg.100g^{-1}$ in *m. semimembranosus* in the Limousine bulls. The fatty acid n-3 ratio was relatively even in both breeds and all the muscles (25–38 $mg.100g^{-1}$). The highest CLA proportion (9.63 $mg.100g^{-1}$) was in MLL of Limousine bulls. Also SAMI *et al.* (2004), OLIVER *et al.* (2006) a ZAPLETAL *et al.* (2009) were interested to explore the changes of fatty acid composition of beef.

MATERIAL AND METHODS

The aim of this work was to evaluate the effect of bull slaughter weight on changes in intramuscular fatty acid composition. 144 Charolais bulls were used to be evaluated. They were reared in a pasture up to their weaning. The animals were fed by clover-grass silage in winter and then they were grazed from the end of April, the pasture carrying capacity was 2.15 animals per 1ha. The bulls were slaughtered at the age of 490–550 days. Nett weight gain per day during fattening was 691 ± 73 g per day. The carcasses (weight ranged from 304 to 383 kg) were classified to the class of meatiness "R" and the class of fattiness "2". The beef samples were excised from carcass at the half cutting level between 8th and 9th rib and analyzed. Intramuscular fat content was extracted (using diethyl ether as a solvent) in the Soxhlet extractor for 6 hours. The extraction was carried out without acid hydrolysis. The fatty acids methyl ester synthesis was conducted with sodium methylate and subsequently with boron trifluoride in methanol. The FAME was analyzed by a gas chromatograph CHROM 5 with a flame ionization detector (FID). The temperature of the column rose from the initial 100 °C up to 250 °C. Nitrogen was used as the carrier gas. Both the injector and the detector (FID) were set at 280 °C. 2µl of the sample was injected into the gas chromatograph equipment for each analysis. The analyzed FAME were identified on the basic of elution times and compared with elution times of standard methyl ester of fatty acid. The standard sample of FAME Mix 37 was used for identification. The Cl-105 integrator was used for quantitative evaluations of chromatographic analyses. Fatty acid levels were expressed as the percentage of total fatty acid content. The results were statistically analysed using the statistical package STATISTICA 9.0, by means of variance analysis: $y_{ij} = \mu + A_i + e_{ij}$, where A = weight categories (500–580 kg; 581–640kg; 641–700 kg), e = residuum. HSD test was used to determine the statistically significant differences.

RESULTS AND DISCUSSION

The variation of the intramuscular fat ratio in beef ranged from 1.14% at the smallest weight group to 1.76 at bulls slaughtered at the highest weight class. Statistically significant difference ($P < 0.05$) in intramuscular fat content from MLT samples was proved among all the weight categories of the slaughtered bulls (Tab. I). The highest average ratios displayed palmitic acid (C16:0), it ranged from 23.75% at bulls from 500–580 kg weight group up to 24.79% at bulls over 641 kg. PADRE *et al.* (2007) presented higher proportion C16:0. The second highest ratios was found in stearic acid (C18:0), that ranged from 22.3% at bulls from 500–580 kg weight group up to 22.9% at bulls 500–580 kg. BUREŠ *et al.* (2006) state lower C18:0 content in Simmental bulls compared to the amount of the same fatty acid in Charolais.

Similar results were published by LABORDE *et al.* (2001) in Simmental and Angus bulls. Statistically significant difference ($P < 0.01$) was established at arachidic acid (C20:0) between 1st and 2nd, respectively 1st and 3rd weight group. ZAPLETAL *et al. (2009)* present statistically important ($P < 0.05$) difference at arachidic acid content between Czech Fleckvieh and Montbeliarde although this acid ratio was lower compared to our results (0.08 respectively 0.1%). To the contrary SCOLLAN *et al.* (2006) introduce the fatty acid composition at the level comparable to our results. The ratios of monounsaturated, di- and polyunsaturated fatty acids within Charolais beef is shown in table II. The lowest content of a fatty acid with one double bond was expressed at eicosenic acid (C20:1), its content graded from 0.36% in the 3rd weight group to 0.53% in bulls slaughtered at 500–580 kg. The average amount of myristooleic acid (C14:1) was 0.70 ± 0.38% with the lowest value of 0.13% and the highest 1.56%. The highest ratio in monogenic acid was in oleic acid (C18:1) at 39.64% with a difference ± 2.932%. Together with increasing slaughter weight ($P < 0.01$) occurred linear growth of this fatty acid composition in beef. Stearic acid is one of the main FA indicating fat hardness. Increased conversion of stearic acid to oleic acid will raise fat softness because beef lipids enhanced with oleic acid have a lower melting point

I: *Fatty acid composition in beef of bulls slaughtered at different slaughter weight*

Indicator		Slaughter weight (kg)				Significant differences*	
		500–580	581–640	641–700	Total	P < 0.05	P < 0.01
	n	52	53	39	144		
Fat	μ	1.14	1.54	1.76	1.46	1–2, 1–3, 2–3	1–3
	s_x	0.54	0.96	0.68	0.79		
C12:0	μ	0.080	0.081	0.074	0.079	-	-
	s_x	0.029	0.030	0.016	0.026		
C14:0	μ	2.547	2.552	2.501	2.537	-	-
	s_x	0.392	0.457	0.406	0.418		
C16:0	μ	23.756	24.804	24.797	24.424	1–2, 1–3	-
	s_x	1.956	2.006	1.935	2.019		
C18:0	μ	22.900	22.397	21.723	22.396	1–3	-
	s_x	2.785	2.769	2.597	2.750		
C20:0	μ	0.467	0.287	0.234	0.338	1–2, 1–3	1–2, 1–3
	s_x	0.308	0.171	0.094	0.239		

* 1: slaughter weight 500–580 kg; 2: 581–640 kg; 3: 641–700 kg

(CHUNG *et al.*, 2006). The concentration of oleic acid has been reported to be positively correlated with beef overall palatability (WESTERLING & HEDRICK, 1979). The average palmitic-oleic acid (C16:1) content was at the level of 3.64 ± 1.16%. Higher ratio (5.6%) of this fatty acid in steer slaughtered at 525 kg is presented by JIANG *et al.* (2010). On the other hand ZAPLETAL *et al.* (2009) introduce results comparable to ours. We proved statistically significant difference (P < 0.01) in myristooleic and oleic acid between bulls slaughtered at 500–580 kg and the weight class of 581–650 kg, respectively between the categories 500–580 kg and 641–700 kg. The average myristooleic (C14:2) content was very low (0.117 ± 0.02%), from that the lowest recorded level was monitored in the 3rd weight category (0.033 ± 0.019%). Similar development was found at eicosadienoic acid (C20:2) when the average content was 0.29 ± 0.09%. Significant difference (P < 0.01) of this fatty acid was detected among all the weight categories. The highest average ratio of dienoic acid was recorded at linolic acid (C18:2) with variation grade from 3.39% at group of bulls 641–700 kg to 3.47% in the lowest weight category (500–580 kg). WARREN *et al.* (2008) published more decreased ratio of C 18:2 (2.93%) in Aberdeen Angus sterr. Also ZAPLETAL *et al.* (2009) present lower content of this fatty acid. Palmitic-oleic acid (C16:2) and linolic acid content was relatively steady within all the weight categories with non significant (P > 0.05) decrease in connection to slaughter weight increasing. The important unit makes the fatty acids with 3 to 6 double bonds whereas the most substantional are linolic acid (C18:3), arachidonic acid (C20:4) and the other "eicosa" acids (C20:3, C20:5, C20:6). The proportion of the polyenic fatty acids in the total amount of fatty acid in beef was relatively low. The average linolic acid (C18:3) content was 0.48 ± 0.19%.The ratio of this fatty acid demonstrated highly significant difference (P < 0.01) between the first and the third groups, respectively between the second and third weight groups of the slaughtered bulls. The highest (P > 0.05) arachidonic acid (C20:4) content was determined in intramuscular fat from the third weight group of bulls (0.36 ± 0.01%) and the lowest (0.32 ± 0.02%) in the second weight group. Statistically evident differences (P < 0.01) in eicosapentaeonic acid content (C20:5) and eicosahexaenoic acid content (C20:6) were found between the first (500–580 kg) and the third (641–700 kg), respectively between the second (581–640 kg) and the third (641–700 kg) weight groups of the slaughtered bulls. There was detected nearly 50% decrease (P < 0.01) of C20:6 content in beef between the bulls slaughtered at the lowest and highest weight category. Quite regular (0.118; 0.127; 0.127%) docosahexaenoic acid content (C22:6) was among all the weight groups. Also similar condition was in adrenic acid content (C22:4), where the ratio graded from 0.07 ± 0.01% (581–640 kg weight category) to 0.08 ± 0.01% (500–580 kg weight category). Statistically evident (P < 0.01) difference was proved at docosapentaeonic content (C22:5) between the first (0.14%) and the second (0.16%), respectively between the first and the third (0.21%) weight group. MARINO *et al.* (2006) present the ratios of n-3 and n-6 fatty acid in beef of young bulls at the level of 6.72% which is 1.03% more than our results (5.69%). ENSER *et al.* (1996) was evaluating fatty acid composition in beef. Their results are comparable to ours, respectively the C20 ratio and C22 PUFA was included in fatty acid profile but their proportion was very low. DE SMET *et al.* (2004) suggested that the difference in FA composition reflected possible genetic differences in FA metabolism. According to LABORDE *et al.* (2001) the selective breeding might be used in order to improve FA composition of intramuscular fat with respect to human health.

II: *Unsaturated fatty acid composition in beef of bulls slaughtered at different slaughter weight*

Indicator		Slaughter weight (kg)				Significant differences*	
		500–580	581–640	641–700	Total	P < 0.05	P < 0.01
	n	52	53	39	144		
C14:1	μ	0.892	0.697	0.459	0.703	1–2, 1–3 2–3	1–2, 2–3
	s_x	0.392	0.340	0.252	0.378		
C16:1	μ	4.320	3.436	2.996	3.636	1–2, 1–3	1–2, 1–3
	s_x	1.215	1.027	0.714	1.158		
C18:1	μ	38.484	39.611	41.213	39.638	1–2, 2–3	1–3, 2–3
	s_x	2.965	2.809	2.321	2.932		
C20:1	μ	0.531	0.404	0.359	0.438	1–2, 1–3	1–2, 1–3
	s_x	0.293	0.155	0.069	0.214		
C14:2	μ	0.187	0.109	0.033	0.117	1–2, 1–3 2–3	1–2, 2–3
	s_x	0.017	0.027	0.019	0.020		
C16:2	μ	0.533	0.516	0.508	0.519	-	-
	s_x	0.093	0.010	0.083	0.093		
C18:2	μ	3.468	3.425	3.392	3.431	-	-
	s_x	1.016	1.042	0.766	0.959		
C20:2	μ	0.502	0.263	0.079	0.299	1–2, 1–3 2–3	1–2, 1–3 2–3
	s_x	0.069	0.047	0.028	0.086		
C18:3	μ	0.351	0.490	0.645	0.482	1–2, 1–3 2–3	1–3, 2–3
	s_x	0.170	0.101	0.109	0.190		
C20:3	μ	0.102	0.102	0.113	0.105	-	-
	s_x	0.029	0.031	0.054	0.046		
C20:4	μ	0.334	0.316	0.357	0.334	-	-
	s_x	0.012	0.019	0.007	0.053		
C20:5	μ	0.117	0.109	0.069	0.101	1–3, 2–3	1–3, 2–3
	s_x	0.039	0.052	0.017	0.036		
C20:6	μ	0.054	0.039	0.025	0.041	1–2, 1–3 2–3	1–3, 2–3
	s_x	0.003	0.002	0.009	0.008		
C22:4	μ	0.080	0.066	0.075	0.074	-	-
	s_x	0.011	0.013	0.020	0.020		
C22:5	μ	0.137	0.160	0.209	0.168	1–2, 2–3	1–2, 2–3
	s_x	0.019	0.058	0.085	0.010		
C22:6	μ	0.118	0.127	0.127	0.124	-	-
	s_x	0.041	0.057	0.040	0.059		

* 1: slaughter weight 500–580 kg; 2: 581–640 kg; 3: 641–700 kg

CONCLUSION

The connection between the slaughter weight of bulls and fatty acid composition in intramuscular fat of MLT was proved. The slaughter weight increase brings higher intramuscular fat content with the highest ratios of saturated fatty acids, from these the most numbered are C16:0, C18:0 and C20:0. To speak about monoenic acids, at the same time when oleic acid increase C14:1; C16:1 a C20:1 are decreasing. Positive dependence was established at polyunsaturated fatty acids between the slaughter weight and C18:1; C18:3 and C22:5 content. Negative was fall of eicosadienic and eicosapentaeonic fatty acid due to their essentiality for human health.

SUMMARY

The aim of this work was to evaluate a slaughter weight influence (500–580; 581–640; 641–700 kg) of Charolaise bulls on intramuscular fat content and fatty acid profile in *musculus longissimus thoracis (MLT)*. The bulls were slaughtered at the age of 490–550 days. The average weight gain during fattening was 691 ± 73 g per day. The carcasses (weight ranged from 304 to 383 kg) were classified to the class of meatiness "R" and the class of fattiness "2". The beef samples (n = 144) were excised from carcass at the half cutting level between 8th and 9th rib and analyzed. The connection between the slaughter weight of bulls and fatty acid composition in intramuscular fat of MLT was proved. The slaughter weight increase brings higher intramuscular fat content with the highest ratios of saturated fatty acids, from these the most numbered are C16:0, C18:0 and C20:0. To speak about monoenic acids, at the same time when oleic acid increase C14:1; C16:1 a C20:1 are decreasing. Positive dependence was established at polyunsaturated fatty acids between the slaughter weight and C18:1; C18:3 and C22:5 content. Negative was fall of eicosadienic and eicosapentaeonic fatty acid due to their essentiality for human health.

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