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Institute of Genetics and Animal Breeding, Jastrzębiec, Poland

The relationship of fatty acid composition and cholesterol content with intramuscular fat content and marbling in the meat of Polish Holstein-Friesian cattle from semi-intensive farming

Zygmunt Litwińczuk[1], Piotr Domaradzki[2,*], Tomasz Grodzicki[2], Anna Litwińczuk[2], Mariusz Florek[2]

[1] Department of Breeding and Conservation of Genetic Resources of Cattle, University of Life Sciences in Lublin, 20-950 Lublin, Poland

[2] Department of Commodity Science and Animal Raw Materials Processing, University of Life Sciences in Lublin, 20-950 Lublin, Poland

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The aim of the investigations was to find out the relationship between the fatty acid composition and cholesterol content with intramuscular fat content and marbling score in the meat of cattle of Polish Holstein-Friesian breed. The fatty acid composition and cholesterol content were both determined in two skeletal muscles of four categories of animals – calves, heifers, young bulls and cows. Significantly higher saturated and polyunsaturated acids proportions and lower monounsaturated acids and cholesterol concentration were found in the meat of calves, whereas the lowest saturated acids and highest cholesterol concentration were obtained in the muscles of cows, and the lowest polyunsaturated acids in heifers. The level of marbling and intramuscular fat were significantly negatively correlated ($-0.28 \leq r \leq -0.73$) with the proportions of C12:0, C14:0, C18:2n6 and C20:4n6 and positively ($0.15 \leq r \leq 0.44$) with C18:1c9 and with cholesterol content. Significant correlations for intramuscular fat with C18:4n3 and marbling with C16:0, C18:0, C18:3n3 and C22:5n3, were also found. The results obtained suggest that marbling is a useful indicator enabling to state the relationship between cholesterol content and the level of some fatty acids in bovine meat.

KEY WORDS: beef / cholesterol / fatty acids / Polish Holstein-Friesian breed

*Corresponding author: piotr.domaradzki@up.lublin.pl

Red meat, including beef, it still very often considered as a source of fat with a high proportion of saturated fatty acids and cholesterol, which are blamed for increasing the risk of illnesses termed diseases of affluence. In fact, most culinary meat currently available on the market is lean with fat content not exceeding 5%. Many authors suggest [Ferguson 2010, McAfee *et al*. 2010] that beef should be treated as a functional food which supplies high-quality protein, vitamins, minerals and fatty acids, including essential unsaturated fatty acids and conjugated linoleic acid (CLA).

A wide variety of factors determine the quality of beef. The important influence of nutrition [Alfaia *et al.* 2006] and breed on the physicochemical and sensory quality of beef, its nutritive value and fatty acid and cholesterol content were stated [Grodzki *et al.* 2001, Bartoň *et al.* 2005, Bureš *et al.* 2006, Litwińczuk *et al.* 2012]. Other authors emphasize a considerable influence of age and sex of the animals [Brugiapaglia *et al.* 2007, Costa *et al.* 2006, Florek *et al.* 2007, Węglarz 2010]. Most of beef produced in Poland comes from cattle used in dairy farming, predominantly the Black-and-White variety of the Polish Holstein-Friesian (PHF) breed [Litwińczuk and Barłowska 2012]. For this reason evaluation of the quality and nutritive value of meat of this breed of is of particular importance.

The aim of this paper was to establish the relationship between the fatty acid composition and cholesterol content with intramuscular fat content and marbling score in the meat of cattle of Polish Holstein-Friesian breed (Black-and-White variety). The fatty acid composition and cholesterol content was determined in *musculus longissimus lumborum* and *semitendinosus* of four categories of cattle *i.e.* calves, heifers, young bulls and cows.

Material and methods

The studies included one hundred animals of Polish Holstein-Friesian cattle of the Black-and-White variety (PHF) comprising 25 calves (aged 50-60 days), 25 heifers, 21 young bulls (aged about 18 months) and 29 cows. Animals were kept on several farms in the Lublin region (eastern Poland) – producers of market milk.

The slaughtered cows were culled for various reasons and their body condition score was at least 3 (on Wildman's 5-point scale). The cows were fed a ration produced on the farms: in winter – maize silage, haylage or hay *ad libitum*, supplemented with grain meal (1-2 kg) and high-protein concentrate (0.5-1 kg) and in the summer – pasture, haylage and maize silage supplemented with concentrate feeds. The feed rations were established for production of 15-20 kg milk. Heifers culled from the breeding herd and the young bulls were fattened on the farm. They received maize silage and haylage and in the summer grass forage as well. The feed rations were supplemented with grain meal. After colostrum period calves were fed with a milk substitute containing total protein 18.5%, crude fat 14.0%, crude fibre 8.0% crude ash 9.6%, vit. A 50600 IU, vit. D_3 4100 IU, vit. E 74 mg and Cu (copper sulphate pentahydrate) 14 mg.

Table 1. Slaughter value, intramuscular fat content (%) in *m. longissimus lumborum* and *m. semitendinosus* and marbling (pts.) of *m. longissimus lumborum* in different cattle categories (mean±se)

Specification	Category			
	cows (n=29)	heifers (n=25)	young bulls (n=21)	calves (n=25)
Body weight (kg)	$505.7^{B}±22.3$	$461.4^{B}±27.9$	$544.7^{C}±22.6$	$82.3^{A}±15.2$
Hot dressing percentage (%)	$48.46^{A}±2.78$	$52.60^{B}±1.27$	$54.81^{C}±1.90$	$57.15^{D}±2.09$
	% of carcases			
Conformation - EUROP				
U	-	-	4.76	ne
R	6.90	20.00	19.05	ne
O	68.97	76.00	71.43	ne
P	24.14	4.00	4.76	ne
Fatness - EUROP				
1	10.34	-	4.76	ne
2	20.69	8.00	28.57	ne
3	27.59	32.00	47.62	ne
4	34.48	48.00	19.05	ne
5	6.90	12.00	-	ne
	m. longissimus lumborum			
Intramuscular fat (%)	$2.19^{C}±1.25$	$2.41^{C}±1.51$	$1.52^{B}±1.22$	$0.20^{A}±0.14$
	m. semitendinosus			
	$2.09^{C}±1.36$	$1.30^{B}±0.89$	$1.07^{B}±1.02$	$0.30^{A}±0.32$
Marbling (pts.)	% of samples			
0	-	-	-	84.00
1	17.24	-	28.57	16.00
2	62.07	48.00	57.14	-
3	20.69	52.00	14.29	-

$^{AB...}$In rows means bearing different superscripts differ significantly at P<0.01.
ne – not evaluated.

The animals were slaughtered in one meat plant. Dressing percentage, EUROP conformation and fatness of cattle are presented in Table 1. Samples of the *longissimus lumborum* (MLL) and *semitendinosus* (MST) muscles for chemical analyses were taken after 24 h of carcass chilling (0-2°C). The marbling score was determined using UNECE [2004] scale (from 0 to 6 pts) between rib 12 and 13. The intramuscular fat (IMF) content in the muscles samples was determined by the Soxhlet method using a Büchi B-811 Extraction System (FLAWIL, Switzerland) [PN-ISO-1444 2000].

Fatty acids and cholesterol content were established following fat extraction according to Folch *et al.* [1957]. Fatty acid methyl esters (FAME) were determined using a Varian CG 3900 gas chromatograph equipped with a flame ionization detector (FID) (Walnut Creek, CA, USA) and CP-Sil 88 capillary column 50 m in length, with an inner diameter of 0.25 mm. The analysis was carried out under variable temperature conditions. The initial temperature of the column oven was 120°C, with a holding time of 3 minutes. The temperature increase rate was 2°C/min and the duration of the entire analysis was 50 minutes. The temperature of the injector was 270°C and the detector temperature was 300°C. The hydrogen flow rate was 25 ml/min, the air flow rate was 350 ml/min and the make-up flow rate was 7 ml/min. Fatty acids were identified based on retention times corresponding to standard mixtures (Supelco Inc., Bellefonte, PA, USA).

Total cholesterol (mg/100 g muscle) was determined using an internal standard (5-α-cholestane) with a Varian CG 3900 gas chromatograph equipped with a flame ionization detector (FID) (Walnut Creek, CA, USA) and CP8943 VF-5ms capillary column. An analysis was carried out under variable temperature conditions. The initial temperature of the column oven was 250°C, with a holding time of 2 min. The temperature increase rate was 3°C/min and the duration of the entire analyses was 16 min. The temperature of the injector was 270°C and the detector temperature 270°C. The hydrogen flow rate was 25 ml/min, the air flow rate 350 ml/min and the make-up flow rate 7 ml/min.

Slaughter value parameters and intramuscular fat content were analysed with a linear model including the fixed effect of the cattle categories. Fatty acid composition data were analysed with a linear model including fixed effects of the muscle, cattle categories and interaction muscle x category. Used was the GLM procedure and the Duncan post-hoc test, using STATISTICA 6.0 software (StatSoft Inc., 2003). The Pearson's correlations were obtained for the content of particular fatty acids and cholesterol with intramuscular fat content and marbling. For the marbling score as a non-parametric characteristic, re-ranking was performed and R Spearman correlation coefficients were calculated. The significance of the correlation coefficients obtained was determined at $P<0.05$ and $P<0.01$.

Results and discussion

Fatty acids content (% of total fatty acids) in the skeletal muscles of cattle in each category showed that C18:1c9, C16:0 and C18:0 were on the highest level (Tab. 2). According to numerous authors [Alfaia *et al.* 2006, Brugiapaglia *et al.* 2007, Florek *et al.* 2007], these are the most important acids occurring in beef. The significantly ($P<0.01$) highest level of C12:0, C14:0, C16:0 was noted in the muscles of calves. The lowest proportion of C14:0 was observed in meat from heifers and the lowest of C16:0 in meat from the young bulls. Moreover, the young bull muscles also contained the highest level of C18:0 ($P<0.01$). Muscles of cows and heifers contained more monounsaturated fatty acids *i.e.* C16:1c9 and C18:1c9, while a higher proportion of C16:1c9 was observed in the fat from muscles of the cows and a higher proportion of C18:1c9 in that of heifers. The lowest level of oleic acid (C18:1c9) was found in the calf muscles. Węglarz [2010] observed higher level of C16:0, C16:1c9 and C18:1c9 and lower of C18:0 in the *longissimus thoracis* muscle of heifers than in that of young bulls of PHF breed. Similar influence of the animal sex on the meat fatty acid profile of young PHF slaughtered cattle reported earlier Florek *et al.* [2007].

Higher level of polyunsaturated fatty acids (PUFA) was found in the meat of calves. The average level of some PUFA (C18:2n6, C18:3n3, C18:4n3, C22:5n3)

Table 2. Fatty acid composition (% of total fatty acids) in *m. longissimus lumborum* and *m. semitendinosus* of different cattle categories (mean±se)

Fatty acid	*M. longissimus*				*M. semitendinosus*				Effects	
	cows n=29	heifers n=25	young bulls n=21	calves n=25	cows n=29	heifers n=25	young bulls n=21	calves n=25	category	muscle
C12:0	$0.06^{A}\pm0.01$	$0.05^{A}\pm0.03$	$0.04^{A}\pm0.03$	$0.50^{B}\pm0.20$	$0.07^{A}\pm0.03$	$0.06^{A}\pm0.03$	$0.05^{A}\pm0.03$	$0.55^{B}\pm0.30$	**	ns
C14:0	$2.81^{A}\pm0.62$	$2.02^{A}\pm0.47$	$2.13^{A}\pm0.10$	$6.87^{B}\pm1.72$	$2.87^{A}\pm0.52$	$2.44^{A}\pm0.38$	$3.04^{A}\pm0.30$	$6.42^{B}\pm1.66$	**	ns
C16:0	$32.05^{B}\pm1.90$	$30.14^{AB}\pm2.21$	$26.77^{A}\pm1.12$	$33.76^{C}\pm3.50$	$31.97^{ab}\pm2.12$	$30.75^{ab}\pm2.68$	$30.16^{a}\pm1.09$	$32.45^{b}\pm3.52$	**	ns
C16:1c9	$4.86^{b}\pm1.64$	$3.81^{a}\pm0.65$	$2.90^{a}\pm0.78$	$3.58^{a}\pm0.80$	$4.66^{B}\pm1.16$	$3.54^{A}\pm0.75$	$3.18^{A}\pm0.52$	$3.78^{A}\pm0.82$	**	ns
C18:0	$14.21^{A}\pm3.34$	$16.86^{A}\pm1.59$	$23.15^{B}\pm4.08$	$14.65^{A}\pm1.87$	$14.47^{ab}\pm3.92$	$17.35^{b}\pm3.07$	$18.90^{b}\pm2.15$	$14.06^{a}\pm1.38$	**	ns
C18:1c9	$43.23^{B}\pm2.55$	$44.78^{B}\pm4.13$	$42.11^{B}\pm3.30$	$34.07^{A}\pm4.02$	$42.77^{B}\pm3.60$	$43.85^{B}\pm4.77$	$40.05^{AB}\pm1.48$	$36.37^{A}\pm3.66$	**	ns
C18:2n6	$1.64^{b}\pm0.82$	$1.19^{a}\pm0.74$	$1.95^{b}\pm0.46$	$3.57^{c}\pm2.28$	$1.77^{A}\pm0.82$	$0.92^{A}\pm0.29$	$3.32^{B}\pm0.26$	$3.39^{B}\pm1.36$	**	ns
C20:0	0.09±0.04	0.13±0.10	0.16±0.05	0.11±0.10	$0.10^{a}\pm0.05$	$0.12^{ab}\pm0.06$	$0.19^{b}\pm0.05$	$0.06^{a}\pm0.04$	*	ns
C18:3n3	$0.49^{A}\pm0.21$	$0.38^{A}\pm0.13$	$0.36^{A}\pm0.03$	$0.94^{B}\pm0.54$	$0.65^{B}\pm0.19$	$0.42^{A}\pm0.21$	$0.40^{A}\pm0.06$	$0.76^{B}\pm0.31$	**	ns
C20:1c11	0.10±0.03	0.12±0.05	0.12±0.08	0.14±0.10	0.11 ± 0.05	0.14±0.06	0.16±0.10	0.18±0.13	ns	ns
C18:4n3	$0.09^{A}\pm0.06$	$0.12^{A}\pm0.11$	$0.11^{A}\pm0.05$	$0.23^{B}\pm0.17$	$0.09^{a}\pm0.05$	$0.10^{ab}\pm0.06$	$0.13^{ab}\pm0.08$	$0.29^{b}\pm0.38$	**	ns
C20:4n6	$0.15^{A}\pm0.09$	$0.09^{A}\pm0.06$	$0.08^{A}\pm0.03$	$1.10^{B}\pm0.63$	$0.19^{A}\pm0.15$	$0.08^{A}\pm0.06$	$0.14^{A}\pm0.07$	$1.16^{B}\pm0.88$	**	ns
C22:5n3	$0.11^{A}\pm0.06$	$0.21^{A}\pm0.25$	$0.04^{A}\pm0.01$	$0.46^{B}\pm0.25$	$0.13^{b}\pm0.07$	$0.07^{a}\pm0.09$	$0.05^{a}\pm0.02$	$0.43^{b}\pm0.20$	**	ns
CLA (c9t11/t10c12)	0.14±0.10	0.18±0.11	0.09±0.05	0.17±0.15	0.16±0.09	0.17±0.06	0.05±0.02	0.17±0.13	ns	ns

CLA – total conjugated linoleic acid (C18:2 c9 t11 and C18:2 t10c12)
$^{Aa...}$In rows means bearing different superscripts differ significantly at: small letters – P<0.05; capital – P<0.01.
Significant differences were determined for each category within the particular muscle.
*P<0.05; **P<0.01; ns – not significant.
The category x muscle interaction term was never significant and is not mentioned.

was several times (even over 10 times for C20:4n6) higher than in the other cattle categories. Earlier results obtained by Brugiapaglia *et al.* [2007] showed that the MLL muscle of calves of local Aosta breed (dairy cattle) had higher proportions of C18:2n6, C20:2n6, C20:3n6 and C20:4n6 than the muscles of young bulls and cows. It was related to the presence of milk in the calf diet and the possibility of hydrogenation of UFA in the rumen of mature animals.

No significant (P>0.05) differences were found in the level of CLA (c9t11 and t10c12). However, obtained amounts were higher in the muscles of heifers and lower in the meat of young bulls. According to many authors [Alfaia *et al.* 2006, Mapiye *et al.* 2012] CLA lowers the total cholesterol level, including the LDL fraction, improving the LDL/HDL ratio in the blood plasma, which is significant in the prevention of ischaemic heart disease and atherosclerosis. The data in Table 2 indicate that neither the muscle type nor the category x muscle interactions significantly influenced the proportions of particular fatty acids.

Muscles of calves contained significantly (P<0.01) more saturated fatty acids (SFA), while the significantly lowest sum of these acids was found in the muscles of the cows (Tab. 3). The calf muscles, despite the relatively high level of SFA, contained significantly (P<0.01) highest proportion of PUFA. Similar results were earlier reported by Costa *et al.* [2006]. However, Brugiapaglia *et al.* [2007] comparing different cattle categories, obtained the highest proportions of SFA and MUFA and the lowest of PUFA in the meat of cows. Among PUFA, the linoleic acid (C18:2n6) and α-linolenic acid (18:3n3) have an important function in the organism. Their long-chain derivatives, *i.e.* arachidonic, eicosapentaenoic and docosahexaenoic acid, exhibit considerable biological activity [Mapiye *et al.* 2012]. High proportion of PUFA in the meat from the calves resulted in the most beneficial PUFA/SFA ratio, which was up to four times lower for the other categories assessed (e.g. in the *semitendinosus* muscle in heifers). The PUFA/SFA ratio obtained in the present study was similar to the values previously noted by Nogalski *et al*. [2014] and Costa *et al.* [2006], which ranged from 0.07 to 0.18 depending on body weight, muscle type, slaughter season, and sex of animals. These ratios seem to be relatively low, as according to Alfaia *et al.* [2006] the recommended PUFA/SFA ratio should be above 0.45.

Cattle category was found to influence significantly (P<0.01) the cholesterol level (Tab. 3). The highest cholesterol concentration in both analysed muscles was noted in cows. In muscles of other cattle categories cholesterol level was significantly lower, ranging from 44.30 to 57.93 mg/100g, alike reported earlier by Bureš *et al.* [2006] and Costa *et al.* [2006]. However, Desimone *et al.* [2013] analysing the quality of commercial beef cuts according to USDA quality grade, found slightly higher cholesterol concentration, ranging from 62.55 to 76.60 mg/100 g. The authors consider cholesterol to be a relatively constant component of meat lipids with breed, sex, and diet having limited influence on cholesterol content. Nevertheless, Morales *et al.* [2012] showed that cholesterol concentration in the *longissimus* muscle is, on average, 10 mg/100g lower in steers kept in a grazing system than in cattle kept in intensive systems. Similarly to Vera

Table 3. Partial sums of fatty acids (% of total fatty acids) and total cholesterol content (mg/100 g muscle) in *m. longissimus lumborum* (MLL) and *m. semitendinosus* (MST) of different cattle categories (mean±se)

Specification	*M. longissimus lumborum*				*M. semitendinosus*				Effects		
	cows n=29	heifers n=25	young bulls n=21	calves n=25	cows n=29	heifers n=25	young bulls n=21	calves n=25	category	muscle	category × muscle
SFA	$49.20^{A}\pm3.41$	$49.21^{A}\pm2.76$	$52.24^{B}\pm3.73$	$55.79^{B}\pm4.62$	$49.47^{A}\pm 3.85$	$50.73^{AB}\pm2.69$	$52.38^{BC}\pm2.97$	$53.57^{C}\pm2.85$	**	ns	*
UFA	$50.79^{C}\pm3.41$	$50.72^{C}\pm2.74$	$47.75^{B}\pm3.72$	$44.20^{A}\pm4.64$	$50.53^{C}\pm 3.84$	$49.30^{BC}\pm4.65$	$47.52^{AB}\pm2.94$	$46.47^{AB}\pm4.66$	**	ns	*
MUFA	$48.20^{C}\pm3.50$	$48.71^{C}\pm3.84$	$45.13^{B}\pm4.09$	$37.71^{A}\pm4.33$	$47.53^{B}\pm4.35$	$47.55^{B}\pm4.97$	$43.49^{A}\pm2.23$	$40.26^{A}\pm4.96$	**	ns	ns
PUFA	$2.60^{A}\pm0.99$	$2.01^{A}\pm1.16$	$2.62^{A}\pm0.48$	$6.49^{B}\pm3.31$	$2.98^{AB}\pm1.11$	$1.75^{A}\pm0.53$	$4.03^{B}\pm0.70$	$6.21^{C}\pm2.50$	**	ns	ns
UFA/SFA	$1.04^{C}\pm0.14$	$1.03^{BC}\pm0.11$	$0.92^{B}\pm0.15$	$0.80^{A}\pm0.15$	$1.03^{B}\pm0.16$	$0.97^{A}\pm0.18$	$0.91^{A}\pm0.13$	$0.87^{A}\pm0.17$	**	ns	*
MUFA/SFA	$0.98^{B}\pm0.14$	$1.00^{C}\pm0.13$	$0.87^{B}\pm0.15$	$0.68^{A}\pm0.13$	$0.96^{B}\pm0.16$	$0.94^{B}\pm0.18$	$0.83^{B}\pm0.13$	$0.76^{A}\pm0.16$	**	ns	*
PUFA/SFA	$0.05^{A}\pm0.02$	$0.04^{A}\pm0.02$	$0.05^{A}\pm0.02$	$0.12^{B}\pm0.07$	$0.06^{AB}\pm0.02$	$0.03^{A}\pm0.01$	$0.08^{B}\pm0.03$	$0.12^{C}\pm0.05$	**	ns	ns
Cholesterol	$67.01^{B}\pm6.50$	$52.18^{A}\pm5.23$	$57.93^{AB}\pm5.31$	$51.33^{A}\pm4.31$	$62.70^{b}\pm5.08$	$48.90^{a}\pm4.12$	$44.30^{a}\pm6.80$	$47.56^{a}\pm3.47$	**	ns	ns

SFA – total of saturated fatty acids; MUFA – total of monounsaturated fatty acids; PUFA – total of polyunsaturated fatty acids.
$^{Aa...}$In rows means bearing different superscripts differ significantly at: small letters – $P<0.05$; capital – $P<0.01$.
Significant differences were determined for each category within the particular muscle.
*$P<0.05$; **$P<0.01$; ns – not significant.

et al. [2009], the present study found no significant influence of the muscle type on total cholesterol content.

High and negative (P<0.01) correlations were shown between the proportions of C12:0 and C14:0 and the level of meat marbling (Tab. 4). A lower (1.5 times) but still significant (P<0.01) correlation was shown between these acids and intramuscular fat content. A similar tendency was also observed for PUFA. The IMF content was significantly (P<0.01) negatively correlated with C18:2n6, C18:4n3 and C20:4n6 acids, while the marbling correlated negatively with the content of C18:2n6, C18:3n3, C20:4n6 and C22:5n3 (P<0.01). Highly significant (P<0.01) and positive correlations were noted for the marbling and IMF with C18:1c9 acid, which is believed to be beneficial for human health due to its hypocholesterolemic, anti-thrombotic and antihypertensive effects [Brugiapaglia *et al.* 2007, Mapiye *et al.* 2012]. A negative correlation ($-0.31 \leq r \leq -0.42$) between marbling and proportions of C14:0, C14:1 and C16:0 acids, and a positive correlation with C18:1 (r = 0.40) were obtained by Inoue *et al.* [2011] in the *trapezius* muscle of Japanese Black steers. A study by Costa *et al.* [2012] analysing the quality of two skeletal muscles (MLL and MST) in the Alentejana and Barrosã breeds showed a highly significant (P<0.001) positive correlation ($0.87 \leq r \leq 0.99$) between intramuscular fat and C14:0, C16:0, C16:1c9, C18:0, C18:1c9 and C18:1c11 acids, a slightly lower correlation with C18:2n6 ($0.43 \leq r \leq 0.69$) and in the case of the *semitendinosus* muscle, with C20:4n6 acid as well (r = 0.56).

The relatively high correlation between cholesterol content and meat marbling (P<0.01) and a three times lower correlation with intramuscular fat content (P<0.05) were stated (Tab. 4). There is no agreement in the available literature as to the relationship between fat content in meat and the amount of cholesterol. A high level of adiposity in meat is not always linked to high cholesterol concentration, as cholesterol is present in large quantities in its free form in cell membranes [Karp 2005]. Hoelscher *et al.* [1988] report that in the muscle tissue of cattle 60-80% of the total cholesterol is localized in cell membranes and 20-40% in the cytoplasm. This means that total cholesterol content in meat is likely to increase with the amount of fat. This is additionally confirmed by Xie *et al.* [2002] who demonstrated that an increased supply of fatty acids in the diet, particularly UFA (including C18:1 and C18:2), significantly contributes

Table 4. Correlations for intramuscular fat content and marbling with particular fatty acids and cholesterol content

Specification	C12:0	C14:0	C16:0	C16:1c9	C18:0	C18:1c9	C18:2n6	C20:0	C18:3n3	C20:1c11	C18:4n3	C20:4n6	C22:5n3	Cholesterol
Intramuscular fat	-0.42**	-0.46**	-0.11	0.11	0.04	0.40**	-0.28**	-0.17	-0.17	-0.14	-0.36**	-0.34**	0.13	0.15*
Marbling	-0.65**	-0.73**	-0.27**	-0.12	0.32**	0.42**	-0.34**	0.04	-0.47**	-0.14	-0.13	-0.58**	-0.49**	0.44**

*P<0.05; **P<0.01.

to esterification and increased secretion of cholesterol lipoproteins by the liver. For instance, Vera *et al.* [2009] analysing the quality of eight cuts of bovine meat found no significant correlation between fat content and cholesterol concentration. Contrary, Dinh *et al.* [2008] demonstrated significant ($P<0.001$) positive relationship ($r = 0.90$) between cholesterol and intramuscular fat content in the *longissimus* muscle of steers of the Angus, Brahman and Romosinuano breeds.

The category of Polish Black-and-White Holstein-Friesian cattle assessed in this study shows significant ($P<0.01$) influence of the animals category on the level of all fatty acids (with the exception of C20:1c11 and CLA), their ratios and total cholesterol concentration. Moreover, significant interactions were noted between cattle category x muscle type for the proportions of SFA and UFA and for the UFA/SFA and MUFA/SFA ratios. The correlation coefficients obtained for the meat of the PHF breed indicate that marbling may be a useful indicator of cholesterol content and the level of some fatty acids in bovine meat.

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