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FATTY ACID COMPOSITION OF MUSCLE IN KRŠKOPOLJE PIGS AND HYBRIDS 12 [1]

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ABSTRACT

The aim of the study was to investigate the fatty acids composition of m. *longissimus dorsi* (LD) in Krškopolje pigs (KP) and maternal hybrids (H12; dam – Slovenian Landrace – line 11, sire – Slovenian Large White). A total of 48 fatteners, 24 of each genotype, were housed in eight pens with six animals in each. They were penned according to genotype and sex. Rearing and feeding conditions were the same for all animals. Pigs were slaughtered in two age groups (G1 and G2) with a two month difference. Twenty-four hours after slaughter, LD samples were taken behind the last rib. Intramuscular fat (IMF) content and fatty acid composition were determined. Statistical analysis was carried out using the GLM procedure in the statistical package SAS/STAT. With IMF content increased saturated fatty acids (SFA), C16:0, monounsaturated fatty acids (MUFA), C16:1n-6 and C18:1n-9 increased with greater IMF content while polyunsaturated fatty acids (PUFA), n-6 PUFA, C18:2n-6, C20:4n-6, n-3 PUFA, ratio PUFA/SFA, and n-6/n-3 decreased with IMF. Gilt's meat had lower n-6/n-3 ratio than barrow meat. In comparison with H12, KP contained more n-3 PUFA and C18:3n-3 and less C20:4n-6. Additionally, the n-6/n-3 ratio was more desirable in KP meat, indicating a better nutritional meat quality of KP than H12. Muscle of fatteners from the first age group (G1) contained more SFA and C16:0 than from the second age group (G2). Less C20:4n-6 and n-3 PUFA were found in G1 than in G2 which is not desirable from a nutritional point of view. Moreover, trends for better PUFA/SFA and n-3/n-6 were obtained in G1 in comparison with G2. Interaction between the genotype and the slaughter group showed the highest content of C18:3n-3 and the lower ratio n-3/n-6 in younger KP.

Key words: pigs / breeds / Krškopolje pig / hybrids / muscles / m. *longissimus dorsi* / intramuscular fat / fatty acid composition / nutritional quality

1 INTRODUCTION

Fatty acid composition of intramuscular fat is an important element in the nutritional quality of pig meat influencing human health (Grundy, 1994). According to the World Health Organisation (WHO/FAO, 2003) recommendations daily consumption of fat should not represent more than 15–30% of total energy intake, containing less than 10% saturated fatty acids (SFA) and between 6 and 10% polyunsaturated fatty acids (PUFA). Furthermore, WHO/FAO (2003) has recommended consumption of 5–8% of n-6 PUFA, 1–2% n-3 PUFA and no more than 1% trans fatty acids. Scollan *et al.* (2006) still recommended that the n-6/n-3 PUFA ratio be limited to 4:1, although DRI (2005) raised it to 10:1. Ulbricht and Southgate (1991) suggested that the ratio of PUFA to SFA (P/S) should exceed 0.4.

Krškopolje pigs (KP) are the only Slovenian indigenous pig breed. As for others indigenous pig breeds are praised for good meat quality. KP are fattier in comparison to commercial breeds (Furman *et al.*, 2010). Good technological quality of KP were observed (Čandek-Potokar *et al.*, 2003) and their meat has more desirable fatty acid composition than commercial fatteners (Furman *et al.*, 2010). The fatty acid composition of m. *longissimus dorsi* in KP was closer to meaty than fatty

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Table 1: *Fatty acid composition (%) of feed, hay and straw*

	Feed and litter material					Feed and litter material			
Item	BEK1	BEK2	Hay	Straw	Item	BEK1	BEK2	Hay	Straw
SFA	18.14	17.98	37.91	40.31	PUFA	58.51	58.34	56.08	43.82
C16:0	14.14	13.86	24.59	23.66	n-6 PUFA	53.44	53.01	17.68	34.28
C18:0	2.86	3.00	2.53	3.21	C18:2n-6	53.34	52.91	17.17	33.30
MUFA	23.35	23.68	6.01	15.87	n-3 PUFA	5.07	5.34	38.40	9.55
C16:1n-7	0.16	0.17	0.59	0.46	C18:3n-3	5.07	5.34	37.20	9.33
C18:1n-9	22.53	22.86	4.62	14.40	PUFA/SFA	3.23	3.25	1.48	1.09
					n-6/n-3	10.54	9.95	0.47	3.67

BEK1 – commercial feed mixture for growers, BEK2 – commercial feed mixture for fatteners, SFA – saturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids

commercial fatteners. Fatty acids composition of other indigenous pig breed were also investigated, as in German Saddle Back pigs (Kuhn *et al*., 1998) and Italian Casertana breed (Salvatori *et al*., 2008).

The present study compares the fatty acid profile of KP and maternal hybrids (H12) where dam is Slovenian Landrace – line 11 and sire Slovenian Large White under the same rearing conditions and feeding regime.

Table 2: *Descriptive statistics for age, weight and intramuscular fat content of m. longissimus dorsi in pigs*

			Age	Weight (kg)		IMF (%)	
Genotype		n	(days)	Mean	SD	Mean	SD
Krškopolje	Start	24	179	37.1	3.7		
	G1	11	292	108.6	10.1	1.83	0.37
	G2	12	362	139.3	9.8	2.30	0.47
Hybrid 12	Start	24	113	41.1	7.2		
	G1	12	226	130.8	11.7	1.12	0.34
	G2	12	296	165.5	10.7	1.24	0.48

n – number of observation, SD – standard deviation, IMF – intramuscular fat, G1, G2 – age group at first second slaughter

2 MATERIAL AND METHODS

The 48 fatteners, six barrows and 18 gilts of KP and 12 barrows and 12 gilts of H12 were housed indoors in eight straw-bedded pens, with six animals of the same genotype and sex per pen. Commercial diet for growers (BEK1) was given manually up to 60 kg and diet for fatteners (BEK2) latter on. Feed restriction depend on growth capacity, thus, KP got 15 % restriction and H12 10 %. Fatty acid composition (Table 1) showed that essential C18:2n-6 fatty acid was predominant in commercial diets, while hay was a good source of essential C18:3n-3 fatty acid. Water was accessible in two nipple drinkers per pen. Hay was added in racks *ad libitum* after feeding.

KP originated from organic farm and was on the average older (179 days) and lighter (37.1 kg) than H12 from commercial farm (113 days and 41.1 kg; Table 2). One KP gilt died during the experiment. After 113 days of fattening, three animals per pen were randomly chosen for slaughter, forming first age group (G1). The second age group (G2) was slaughtered, at the time when younger and faster growing H12 pigs reached the similar age as G1 of KP (around 290 days). Twenty-four hours after slaughters, samples of m. *longissimus dorsi* were taken behind the last rib; vacuum packed and stored at −21 °C until the analyses.

Intramuscular fat (IMF) was determined using the Weibull and Stoldt method (AOAC, 1997). Average intramuscular fat (IMF) content in KP was 1.83% in G1 and 2.30% in G2 (Table 2), while H12 muscles had less IMF: 1.12% in G1 and 1.24% in G2. Fatty acid composition was analysed using the Park and Goins (1994) method. Statistical model included effects of sex, genotype, age group at slaughter, genotype * age group interaction as class effects and IMF content as covariate. The GLM procedure in SAS/STAT was used (SAS, 2008).

3 RESULTS AND DISCUSSION

Saturated and monounsaturated fatty acids in m. *longissimus dorsi* were increased with IMF content (Table 3), especially C16:0, C16:1, and C18:1. Cameron and Enser (1991) reported similar trends in proportions

Table 3: *Least square means and standard errors for saturated (SFA) and monounsaturated (MUFA) fatty acids composition (%) in m. longissimus dorsi*

		SFA	C16:0	C18:0	MUFA	C16:1n-7	C18:1n-9
IMF	b	**1.91 ± 0.46**	**1.32 ± 0.30**	0.34 ± 0.22	**7.03 ± 0.84**	**0.62 ± 0.17**	**6.43 ± 0.78**
	P-value	**0.0002**	**<.0001**	0.1402	**<.0001**	**0.0010**	**<.0001**
Sex	Barrows	34.49 ± 0.30	21.76 ± 0.20	11.01 ± 0.15	41.99 ± 0.56	2.95 ± 0.11	38.13 ± 0.52
	Gilts	34.18 ± 0.24	21.51 ± 0.15	11.01 ± 0.11	42.14 ± 0.43	2.98 ± 0.09	38.29 ± 0.40
	P-value	0.4188	0.3456	0.9770	0.8321	0.8170	0.8124
Genotype	KP	34.37 ± 0.35	21.73 ± 0.23	10.95 ± 0.17	42.38 ± 0.65	3.08 ± 0.13	38.39 ± 0.60
	H12	34.30 ± 0.33	21.54 ± 0.21	11.07 ± 0.16	41.75 ± 0.60	2.84 ± 0.12	39.03 ± 0.55
	P-value	0.9051	0.6166	0.6644	0.5458	0.2690	0.7044
Group	G1	**34.73 ± 0.27**	**21.92 ± 0.18**	11.11 ± 0.13	42.36 ± 0.50	3.07 ± 0.10	38.44 ± 0.46
	G2	**33.93 ± 0.27**	**21.34 ± 0.18**	10.91 ± 0.13	41.78 ± 0.50	2.86 ± 0.10	37.98 ± 0.46
	P-value	**0.0488**	**0.0302**	0.2838	0.4232	0.1655	0.4955
Genotype * Group	KP*G1	34.67 ± 0.40	22.00 ± 0.27	10.96 ± 0.20	43.19 ± 0.74	3.24 ± 0.15	39.07 ± 0.68
	KP*G2	34.07 ± 0.50	21.46 ± 0.33	10.94 ± 0.24	41.57 ± 0.91	2.93 ± 0.19	37.71 ± 0.85
	H12*G1	34.79 ± 0.43	21.84 ± 0.28	11.27 ± 0.21	41.52 ± 0.78	2.90 ± 0.16	37.80 ± 0.73
	H12*G2	34.81 ± 0.40	21.23 ± 0.26	10.87 ± 0.20	41.98 ± 0.74	2.80 ± 0.15	38.25 ± 0.68
	P-value	0.6131	0.8875	0.3009	0.1361	0.4699	0.1626

IMF – intramuscular fat; b – regression coefficient; KP – Krškopolje pigs, H12 – hybrid 12; G1, G2 – group at first, second slaughter

of SFA and MUFA in Duroc and British Landrace. IMF content of m. *longissimus dorsi* varied between 0.59% and 3.00%. Larger content of SFA (1.91%) per unit and MUFA (7.03%) per unit is related to larger IMF (Table 3). After adjustment for IMF, sex did not affect content of saturated and monounsaturated fatty acids (Table 3), which was in agreement with results of Salvatori *et al.* (2008).

Genotype did not affect SFA and MUFA (Table 3). SFA are mainly related to cholesterol level, while MUFA have no effect on human health inside recommendations (Grundy, 1994). Thus, there were no differences between KP and H12 meat in terms of effect on human health if they had the same fed. The results are similarly to Casertana pigs and their crossbreeds with Large White, which did not differ in proportion of saturated and monounsaturated fatty acids (Salvatori *et al.*, 2008). However, results in the study were not in agreement with Kuhn *et al.* (1998) who found more SFA in the muscle of indigenous German Saddle Back than German Landrace.

Younger pigs (G1) contained more SFA and C16:0 then older pigs (G2; Table 3). Similarly Salvatori *et al.*, (2008) found less SFA and C16:0 in lighter and younger than heavier and older Casertana pigs and their crossbreeds, where lighter fatteners also had less IMF in comparison to heavier.

As expected, PUFA in m. *longissimus dorsi* decreased with IMF (Table 4). Cameron and Enser (1991) also reported PUFA decreasing with IMF. The same considered for all n-6 and n-3 PUFA (Table 4), except essential C18:3n-3, which was constant regardless of IMF content. SFA and MUFA are accumulated in adipose tissue as energy reserve, while PUFA contained the essential fatty acids supporting metabolic processes in the body. Therefore, it is expected that SFA and MUFA content increased with increased fatness in adipose tissue as well as IMF (Table 3). With IMF content, undesirable decreasing P/S was observed and desirable decreasing n-6/n-3 was found (Table 4). The sex did not affect PUFA content (Table 4) while Casertana gilts contained more PUFA, C18:2n-2 and C18:3n-3 than barrows (Salvatori *et al.*, 2008). Furthermore, KP gilts had a more desirable n-6/n-3 ratio in comparison to barrows (Table 4), while Casertana gilts had nutritional better P/S ratio (Salvatori *et al.*, 2008).

PUFA content did not differ between genotypes (Table 4). The same was concluded by Salvatori *et al.* (2008) comparing Casertana pigs and their crossbreds with Large White having similar IMF, while Kuhn *et al.* (1998) observed larger IMF and less PUFA in indigenous German Saddle Back (8.4%) than in German Landrace (19.9%). Furthermore, KP contained less C20:4n-6 (Table 4) and more n-3 PUFA rich in C18:3n-3. Higher content of essential C18:3n-3 fatty acid, which is a precursor for other necessary long chain fatty acids, indicated better nutritional quality of KP than H12 meat. However, other indigenous breeds showed no differences in

Table 4: *Least square means and standard errors for polyunsaturated fatty acids (PUFA) composition (%) and rations in m. longissimus dorsi*

		PUFA	n-6	C18:2 n-6	n-3	C18:3n-3
IMF	b	**−8.94 ± 1.01**	**−8.32 ± 0.95**	**−5.21 ± 0.63**	**−0.62 ± 0.07**	−0.02 ± 0.03
	P-value	**<.0001**	**<.0001**	**<.0001**	**<.0001**	0.5890
Sex	Barrows	23.51 ± 0.67	21.56 ± 0.63	15.70 ± 0.42	1.86 ± 0.05	0.70 ± 0.02
	Gilts	23.68 ± 0.52	21.66 ± 0.48	15.51 ± 0.32	1.94 ± 0.04	0.71 ± 0.02
	P-value	0.8476	0.9030	0.7170	0.2585	0.8093
Genotype	KP	23.25 ± 0.78	21.11 ± 0.73	15.60 ± 0.49	**2.05 ± 0.06**	**0.78 ± 0.02**
	H12	23.95 ± 0.72	22.11 ± 0.67	15.61 ± 0.45	**1.75 ± 0.05**	**0.63 ± 0.02**
	P-value	0.5776	0.3943	0.9887	**0.0020**	**0.0248**
Group	G1	22.91 ± 0.60	21.00 ± 0.56	15.40 ± 0.37	**1.83 ± 0.04**	0.70 ± 0.02
	G2	24.28 ± 0.60	22.22 ± 0.56	15.81 ± 0.37	**1.97 ± 0.04**	0.72 ± 0.02
	P-value	0.1183	0.1357	0.4499	**0.0248**	0.4657
Genotype * Group	KP*G1	22.14 ± 0.89	20.05 ± 0.83	15.14 ± 0.55	2.00 ± 0.06	**0.80[a] ± 0.03**
	KP*G2	24.36 ± 1.10	22.16 ± 1.03	16.06 ± 0.68	2.10 ± 0.08	**0.77[ab] ± 0.03**
	H12*G1	23.69 ± 0.94	21.94 ± 0.88	15.66 ± 0.59	1.66 ± 0.07	**0.59[c] ± 0.03**
	H12*G2	24.21 ± 0.88	22.28 ± 0.83	15.56 ± 0.55	1.84 ± 0.06	**0.66[bc] ± 0.03**
	P-value	0.3074	0.2546	0.3244	0.5038	**0.0306**

P/S – polyunsaturated/saturated fatty acids; b – regression coefficient; IMF – intramuscular fat; KP – Krškopolje pigs, H12 – hybrid 12; G1, G2 – group at first, second slaughter; Values estimates with different superscript differ within the column

Table 5: *Least square means and standard errors for dietary rations in m. longissimus dorsi*

		P/S	n-6/n-3
IMF	b	−0.30 ± 0.04	−0.65 ± 0.20
	P-value	<.0001	0.0021
Sex	Barrows	0.69 ± 0.02	11.47 ± 0.13
	Gilts	0.70 ± 0.02	11.06 ± 0.10
	P-value	0.6381	0.0212
Genotype	KP	0.68 ± 0.03	10.11 ± 0.15
	H12	0.71 ± 0.03	12.43 ± 0.14
	P-value	0.4971	<.0001
Group	G1	0.67 ± 0.02	11.43 ± 0.12
	G2	0.73 ± 0.02	11.10 ± 0.12
	P-value	0.0641	0.0580
Genotype * Group	KP*G1	0.64 ± 0.03	9.96[c] ± 0.17
	KP*G2	0.72 ± 0.04	10.26[b] ± 0.22
	H12*G1	0.69 ± 0.03	12.91[a] ± 0.19
	H12*G2	0.73 ± 0.03	11.95[a] ± 0.17
	P-value	0.5656	0.0004

P/S – polyunsaturated/saturated fatty acids; b – regression coefficient; IMF – intramuscular fat; KP – Krškopolje pigs, H12 – hybrid 12; G1, G2 – group at first, second slaughter; Values estimates with different superscript differ within the column

some polyunsaturated fatty acids content (Salvatori *et al.*, 2008) or even lower n-3 content (Kuhn *et al.*, 1998) in comparison with other hybrids. The differences were larger in Furman *et al.* (2010), where animals were fed typical for each breeds.

The age group did not affect total PUFA content (Table 4), while G2 contained more C20:4n-6 and n-3 PUFA in comparison with G1. In essential C18:2n-6 and C18:3n-3 fatty acid content no differences were found between G1 and G2 (Table 4), while heavier and older Casertana pigs had more PUFA and both essential fatty acids compared to lighter and younger ones (Salvatori *et al.*, 2008). M. *longissimus dorsi* of KP from G1 contained more C18:3n-3 (0.80%) than the same age, G2 (0.66%) and younger, G1 (0.59%) H12 (Table 4).

Fatty acids ratios indicating better meat quality in older (G2) than younger (G1) group (Table 5). Interaction between genotype and age groups showed the most desirable C18:3n-3 content and n-6/n-3 proportion in KP from G1, while they were less desirable in both groups of H12 (Table 4). Moreover, KP from G1 was the only group with n-6/n-3 ratio (9.96) below the limit set in DRI (2005). The differences in n-3 PUFA and C18:3n-3 content lead to more desirable n-6/n-3 ratio in KP than H12. More desirable n-6/n-3 ratio was implied also in KP in comparison to three groups of commercial fatteners

(Furman *et al*., 2010), where the greatest difference was between fattier pigs and KP. The value exceeds the desirable limit of 4:1 (Table 4) according to Scollan *et al*. (2006), but is near the DRI (2005) limit 10:1.

4 CONCLUSION

Saturated and monounsaturated fatty acids increased and polyunsaturated fatty acids decreased with IMF content. Thus, larger amount of IMF was less desirable from nutritional point of view. Better fatty acids profile was observed in m. *longissimus dorsi* of Krškopolje pigs than hybrids 12. Older and heavier pigs had nutritionally more desirable meat than younger and lighter fatteners.

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