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Content of lipid components in *m. longissimus dorsi* of progeny of the boars descending from reciprocal crossing of the Pietrain and Duroc breeds

Summary

The study has been carried out on 72 fatteners being the offspring of crossbreed sows x Pietrain boars (group I) and hybrid boars of the ♂ Pietrain x ♀ Duroc breeds (group II) and, on the ♀ Duroc x ♂ Pietrain breed (group III). In *m. longissimus dorsi*, the content of dry matter, protein, intramuscular fat and total cholesterol has been determined. In the intramuscular fat of the muscle, the composition of the fatty acids has been determined. The hybrid boars with the participation of the Duroc breed (groups II and III) caused the increase ($P \leq 0.01$) of the intramuscular fat and of total cholesterol in *m. longissimus dorsi* of their offspring, in comparison with the progeny of the Pietrain boars. However, the bigger quantity of those components ($P \leq 0.01$) has been ascertained in the muscle of progeny of the hybrid boars, where the Duroc breed was in the position of the father (group III), in comparison with the reverse combination (group II). The intramuscular fat of the *m. longissimus dorsi* of progeny of the hybrid boars D x Pi (group III), contained more ($P \leq 0.01$) SFA and less ($P \leq 0.01$) UFA, including PUFA, in comparison with the progeny of the Pi boars (group I) and of the hybrid boars Pi x D (group II). The content of the aforementioned acids in fat of the muscles of the fatteners from the groups I and II, was similar. The gilts were characterised by better meatiness ($P \leq 0.01$) and they contained less ($P \leq 0.01$) intramuscular fat and of total cholesterol in *m. longissimus dorsi*, in comparison with the barrows. The fat of the gilts muscle contained less ($P \leq 0.01$) of SFA and more ($P \leq 0.01$) of PUFA, in comparison with barrows.

Key Words: Pietrain, Duroc, reciprocal crossing, fatty acids, cholesterol, fattening pig, sex

Zusammenfassung

Titel der Arbeit: Gehalt an Lipidkomponenten im *M. longissimus dorsi* der Nachkommen von Ebern aus reziproken Kreuzungen mit den Rassen Pietrain und Duroc

Die Untersuchungen wurden an 72 Mastschweinen (weibliche und kastrierte männliche Tiere) als Nachkommen von Kreuzungssauen (Polish Landrace x Large White) mit Ebern der Rasse Pietrain (Gruppe I) sowie Kreuzungsebern aus ♂ Pietrain x ♀ Duroc (Gruppe II) und ♂ Duroc x ♀ Pietrain (Gruppe III) durchgeführt. Im *M. longissimus dorsi* wurde der Gehalt an Trockenmasse, Protein, intramuskulärem Fett und Gesamtcholesterin ermittelt, ebenso die Fettsäurezusammensetzung des intramuskulären Fett. Die Nachkommen der Kreuzungseber mit einem Duroc-Anteil in den Gruppen II und III wiesen einen höheren Anteil an intramuskulärem Fett sowie Gesamtcholesterin im M.l.d. (*M. longissimus dorsi*) auf ($P \leq 0,01$) als die Pietrain Nachkommen (Gruppe I). Bei den beiden Duroc-Gruppen lag der Gesamtcholesteringehalt in der Gruppe III, bei der der Duroc-Eber auf der Vaterseite stand, signifikant am höchsten. Das intramuskuläre Fett im M.l.d. der Nachkommen von Kreuzungsebern der Gruppe III enthielt auch mehr gesättigte Fettsäuren (SFA) und weniger ungesättigte Fettsäuren (UFA), darunter auch die mehrfach ungesättigten Fettsäuren (PUFA), im Vergleich zu den Mastschweinen der Gruppen I und II ($P \leq 0,01$), die etwa gleiche Werte erreichten. Die weiblichen Masttiere wiesen im M.l.d. signifikant höhere Proteingehalte bei einem geringeren Anteil an intramuskulärem Fett auf. Das intramuskuläre Fett enthielt signifikant weniger SFA, bei mehr PUFA, als bei den männlichen Kastraten.

Schlüsselwörter: Pietrain, Duroc, reziproke Kreuzung, Fettsäuren, Cholesterin, Mastschweine, Geschlecht

Introduction

The improvement of pigs towards increase of meatiness caused a significant decrease of intramuscular fat content in meat (LENGERKEN et al., 1988; DE VRIES et al.,

1994; SELLIER, 1998; JACYNO et al., 1998; FALKENBERG et al., 1999), which results of worsening of brittleness, juiciness and savoury of meat. It's because the said features are positively correlated with the content of intramuscular fat (DE VOL et al., 1988; CAMERON, 1990; MEYER, 1991; WOOD et al., 1996; EIKELENBOOM et al., 1996; FISCHER et al., 2000). The studies over genetic conditioning of intramuscular fat content showed influence of H-FABP (heart fatty acid – binding protein) gene on the content of that component in the meat of pigs (VAN ERP et al., 1997; GERBENS et al., 1999). Also, a relation between the presence of A – FABP gene (adipocyte fatty acid) and content of intramuscular fat – without any influence of that gene on back fat thickness - has been demonstrated (GERBENS et al., 1998).

Thus, earlier observations (HOVENIER et al., 1993), that intramuscular fat level is correlated to some small degree only with pork fat thickness, have been confirmed. An independent selection, with regard to both presented features, enables to obtain pigs with thin pork fat and good sensorial properties of meat.

Fast increase of intramuscular fat in the meat of the fatteners, one can obtain by crossing, through application of adequate breeds and crossing variants (LENARTOWICZ and KULISIEWICZ, 1998; BLANCHARD et al., 1999; LAUBE et al., 2000).

The increase of intramuscular fat improves sensorial properties of meat (savory, juiciness, brittleness) however, it has a negative influence with regard to its dietetic value. Together with the increase of intramuscular fat, increase of saturated fatty acids and of cholesterol and, the concentration of polyunsaturated fatty acids in meat is decreasing at the same time (CAMERON and ENSER, 1991; EIKELENBOOM et al., 1996; LENARTOWICZ and KULISIEWICZ, 1998; DORADO et al., 1999; BIEDERMANN et al., 2000b).

The results of the tests are indicating that the content of fatty acids and the cholesterol level in the meat of pigs - they can be determined genetically (KELLOG et al., 1977; LENARTOWICZ and KULISIEWICZ, 1998; LAACK and SPENCER, 1999). The pigs of the Pietrain breed are rather commonly used as a paternal component in the commercial crossing. It is commonly known that the pigs of this breed are characterised by a very high meatiness, however, their meat quality is poor. Their high stress susceptibility as well as weakness of viability and sexual activity are the factors that hinder the use of pure-bred Pietrain boars. Therefore, it has been suggested that hybrid boars with some Pietrain genes share should be used in pig crossing, which would alleviate mentioned shortcomings of the breed, at the same time maintaining the high meatiness of Pietrain breed. Among the meat breeds, Pietrain pigs contain least intramuscular fat (WARRISS et al., 1990), which results in low sensory quality of the meat. The meat of the Duroc breed contains the highest quantity of intramuscular fat (WARRISS et al., 1990; KALLWEIT and BAULAIN, 1995). The pigs of the Duroc breed are used for mating with high-meatiness breeds, in order to increase the intramuscular fat content (LAUBE et al., 2000; FISCHER et al., 2000). It is still in dispute whether the Duroc breed should be a maternal or a paternal side in interbreed crossing.

In the researches presented herewith, the hybrid boars coming from reciprocal crossing of the Pietrain and Duroc breeds, have been used for the production of fatteners. The scope of the said researches was to determine which of the crossing variants, namely - ♂Pi x ♀D or ♂D x ♀Pi is more favourable, as far as, the meat quality of those boars

offspring is concerned. The comparative group were the fatteners after pure-bred boars of the Pietrain breed.

Materials and methods

The research material consisted of testes of the *m. longissimus dorsi* of the offspring of the hybrid sows of Polish Landrace (PL) x Polish Large White (PLW) and the boars of the hybrids coming from the reciprocal crossing of the Pietrain and the Duroc breeds ($\text{♂Pi} \times \text{♀D}$ and $\text{♂D} \times \text{♀Pi}$). Each group of fathers was represented by 3 boars. The tests covered 72 fatteners (36 gilts and 36 barrows) altogether, divided into 3 groups - according to the scheme of the trial (Tab. 1).

Table 1
Experimental design

Sows	Boars	Experimental group of fatteners	Number of fatteners in group	
			Gilts	Barrows
PL x PLW	Pi	I	12	12
	$\text{♂Pi} \times \text{♀D}$	II	12	12
	$\text{♂D} \times \text{♀Pi}$	III	12	12

The fatteners were kept in separate pens and they were fed with a balanced rations. During all the fattening time (30-100 kg of body weight) one feed mixture, containing in 1 kg: 13 MJ of metabolizable energy, 162g of crude protein, 8.6 g of lys and 5.6 g of met + cys, have been applied. The fatteners were slaughtered at 100 kg of body weight. The meatiness evaluation was carried out according to the methodology applied in the Polish Pig Testing Stations (RÓŻYCKI and RAB, 1994).

The chemical analyses have been carried out basis *m. longissimus dorsi* tests, extracted from between 1st and 4th lumber vertebra. The meat tests were ground and homogenized. Next, they were frozen at -22°C temperature. Before the chemical analysis, the tests were defrosted and determined:

- dry matter and protein, with the Weende analysis;
- intramuscular fat, with the Weibull Stoldt method;
- total cholesterol, according to RHEE et al. (1982).

In the lipid extracts of the *m. longissimus dorsi*, the contents of the fatty acids basis gas chromatography method has been determined when previous saponification and estrification of 14% BF₃ in methanol have been made. The partition of fatty acids has been carried out in the Philips PU – 4550 gas chromatograph.

The results have been statistically worked out using the STATISTICA PL Programme, applying two-factors variance analysis, considering influence of testing group of fatteners and sex and, interaction between them.

Results

The carcass leanness and the chemical composition of *m. longissimus dorsi* of the fatteners are presented in Table 2. The meatiness of the progeny was similar for the boars coming from the reciprocal crossing of the Pietrain and Duroc breeds (groups II and III) and was lower by 2.5% ($P \leq 0.01$) in comparison with the fatteners derived from Pietrain boars (group I).

Dry matter of the meat ranged from 28.10 g (group II) to 27.48 g/100 g of fresh tissue (group I). Protein content was also the highest in the muscle of the progeny of Pi x D sires (group II), and the difference in relation to group I was statistically significant

($P \leq 0.01$). The intramuscular fat content of *m. longissimus dorsi* for the progeny of pure-bred Pietrain boars was the lowest (2.03 g/100 g fresh tissue) and was very similar to the value obtained by MEYER's (1991), LENARTOWICZ and KULISIEWICZ (1998) for the hybrids Pietrain x (Large White x Landrace). The muscle intramuscular fat content for the progeny of the hybrid boars with share of the Duroc breed (groups II and III) was significantly higher ($P \leq 0.01$) than that of the progeny of Pietrain boars, and was respectively 2.63 and 3.14 g/100 g fresh tissue. A significant difference ($P \leq 0.01$), relating to the content of the component, was also observed between the group II and group III. Total cholesterol content in the muscle of the progeny of Pietrain boars was lower ($P \leq 0.01$) than in the muscle of the fatteners derived from hybrid boars coming from reciprocal crossing of the Pietrain and Duroc breeds (II and III groups). The hybrid boars with the Duroc breed in the sire position (group III) caused a higher ($P \leq 0.01$) increase in the muscle cholesterol of their progeny in comparison with the reverse combination (group II).

The gilts, in comparison with the barrows, had more ($P \leq 0.01$) meat in carcass. In *m. longissimus dorsi* of the gilts, higher ($P \leq 0.01$) protein and lower ($P \leq 0.01$) intramuscular fat content was observed as compared with the muscles of the barrows. Total cholesterol content in the muscles of the gilts was lower than in the muscles of the barrows, however, the differences were statistically insignificant.

Table 2

Carcass meatiness and chemical composition of *m. longissimus dorsi* (Fleischanteil und chemische Zusammensetzung des *M. longissimus dorsi*)

Item		Groups – progeny after boars			Sex		Interaction group x sex
		I Pi	II ♂Pi x ♀D	III ♂D x ♀Pi	Gilts	Barrows	
Carcass meatiness %	\bar{x} s	55.2 ^A 3.21	52.7 ^B 2.52	52.8 ^B 3.27	55.4 ^A 2.70	51.8 ^B 2.61	**
<i>In m. longissimus dorsi</i> (in 100g fresh tissue):							
Dry matter (g)	\bar{x} s	27.48 0.34	28.10 0.57	27.95 0.68	27.63 0.54	28.05 0.59	NS
Protein (g)	\bar{x} s	23.28 ^A 1.32	24.34 ^B 1.38	23.78 0.86	24.19 ^A 1.14	23.40 ^B 1.28	*
Intramuscular fat (g)	\bar{x} s	2.03 ^A 0.28	2.63 ^B 0.52	3.14 ^C 0.64	2.38 ^A 0.58	2.82 ^B 0.69	**
Total cholesterol (mg)	\bar{x} s	58.3 ^A 2.30	63.9 ^B 2.53	66.0 ^C 3.09	62.0 4.35	63.4 3.92	**

A,B,C (group I,II,III) - $P \leq 0.01$; A,B (sex) - $P \leq 0.01$; Interaction group x sex - ** $P \leq 0.01$; * $P \leq 0.05$; NS – non significant.

Fatty acids composition (Tab. 3) was the least favourable in the *m. longissimus dorsi* intramuscular fat of the progeny of the D x Pi hybrid boars (III group). In the muscles of this group of fatteners, higher ($P \leq 0.01$) level of SFAs, including C_{16:0} and C_{18:0}, and lower ($P \leq 0.01$) UFAs content was observed in comparison with the fatteners coming from Pi sire (group I) and Pi x D (group II). The PUFAs content, including C_{18:2}, C_{18:3} n-6 and C_{20:4}, in the muscle fats of the group III fatteners, in comparison with the groups I and II, was also significantly lower. The muscle content of SFAs and UFAs, including PUFAs, was similar for the fatteners of groups I and II. Within

polyunsaturated fatty acids, statistically significant differences occurred only for the C_{18:3} n-6 and C_{18:3} n-3 content, with higher values for the group I of fatteners.

Table 3

Fatty acids content in intramuscular fat of the *m. longissimus dorsi* (% of total fatty acids) (Fettsäuren im intramuskulären Fett *M. longissimus dorsi*) (in % der Gesamtfettsäuren))

Fatty acids		Groups – progeny after boars			Sex		Inter-action group x sex
		I Pi	II ♂Pi x ♀D	III ♂D x ♀Pi	Gilts	Barrows	
Myristic	C14:0	1.30	1.37	1.35	1.29 ^A	1.38 ^B	NS
Palmitic	C16:0	24.17 ^A	24.53	24.84 ^B	24.01 ^A	25.02 ^B	NS
Palmitoleic	C16:1	4.59	4.74	4.70	4.60 ^a	4.75 ^b	**
Stearic	C18:0	11.23	10.93 ^A	11.77 ^B	11.05 ^A	11.67 ^B	*
Oleic	C18:1	44.60	44.59	44.40	44.58	44.48	NS
Linoleic	C18:2 n-6	9.39 ^a	9.26 ^a	8.64 ^b	9.74 ^A	8.47 ^B	NS
γ - Linolenic	C18:3 n-6	0.33 ^{Aa}	0.23 ^b	0.15 ^{Ba}	0.28 ^a	0.19 ^b	NS
α - Linolenic	C18:3 n-3	0.59 ^A	0.47 ^B	0.48 ^B	0.52	0.51	**
Arachidic	C 20:0	0.54 ^{Aa}	0.46 ^B	0.48 ^b	0.51 ^a	0.47 ^b	**
Gadoleinic	C 20:1	1.28 ^{Aa}	1.11 ^b	1.05 ^B	1.07 ^a	1.22 ^b	NS
Eicosadienoic	C 20:2	0.45 ^A	0.37 ^B	0.48 ^A	0.44	0.43	NS
Eicosatrienoic	C 20:3	0.23	0.20	0.19	0.20	0.21	NS
Arachidonic	C 20:4 n-6	0.96 ^a	1.03 ^A	0.82 ^{Bb}	1.13 ^A	0.74 ^B	NS
Other fatty acids		0.34	0.68	0.62	0.55	0.44	
Saturated acids	(SFA)	37.19 ^A	37.47 ^A	39.21 ^B	37.39 ^A	39.10 ^B	NS
Unsaturated acids	(UFA)	62.44 ^A	62.08 ^A	60.80 ^B	62.59 ^a	60.90 ^b	NS
Monounsaturated acids	(MUFA)	50.47	50.44	50.10	50.26	50.35	NS
Polyunsaturated acids	(PUFA)	11.99 ^A	11.63 ^a	10.72 ^{Bb}	12.34 ^A	10.54 ^B	NS

A,B - P≤0.01; a,b - P≤0.05; Interaction group x sex - ** P≤0.01; * P≤0.05; NS – non significant

Discussion

As was anticipated, the hybrid fatteners of group I, with the highest proportion of the Pietrain breed, achieved the best meatiness. The increase in meatiness with the increase of Pietrain genes proportion in hybrid genotype has also been confirmed by other authors, inter alia: MC KAY et al. (1982), MEYER (1991), LENARTOWICZ and KULISIEWICZ (1998) and GÖDEKE et al. (1998). The use of hybrid boars for the production of the fatteners, with addition of the Duroc breed (PixD and DxPi) increased intramuscular fat content, yet decreased the carcass leanness in comparison with the progeny of pure-bred Pietrain sires (Tab. 2). Thus, the observations by other authors have been confirmed (BROOKS, 1998; LENARTOWICZ and KULISIEWICZ, 1998; BLANCHARD et al., 1999; BRANDT, 1999; FISCHER et al., 2000) that application of the Duroc breed in crossing programmes increases meat intramuscular fat content, however, without any decrease in carcasses leanness. The studies by LAUBE et al. (2000) also demonstrated that a Duroc portion in the pig genotype increases the content of intramuscular fat. The results in Table 2 show that the hybrid boars D x Pi caused an increase of *m. longissimus dorsi* intramuscular fat content of their progeny by about 16% (P≤0.01) in comparison with the boars from reciprocal combination (Pi x D). The fat content for the studied fatteners oscillated between 2.03 and 3.14 g/100 g fresh tissue and fell within the optimal limits presented by other authors. According to BEJERHOLM and BARTON-GADE (1986) and

LAUBE et al. (2000), the intramuscular fat content in the range between 2% and 2.5% ensures good consumption quality of pork meat. DE VOL et al. (1998) established that the meat with 2.5-3% of intramuscular fat content — 2.5-3.5% according to FERNANDEZ et al. (1999) — is characterised by better consumption quality. Many authors (DE VOL et al., 1998; CAMERON, 1990; MEYER, 1991; WOOD et al., 1996; EIKELENBOOM et al., 1996; FISCHER et al., 2000; BAULAIN et al., 2000) observed positive correlation between the content of intramuscular fat and sensory traits of the meat (flavour, tenderness, juiciness). Presumably, the increase in meat intramuscular fat of the progeny of hybrid boars with share of the Duroc breed (groups II and III) would go along with an improvement of consumption quality of the meat. BEJERHOLM and BARTON-GADE (1986) stated that the differences in sensory characteristics of the meat were perceptible only if the level of the intramuscular fat exceeded 2%.

Along with an increase of *m. longissimus dorsi* intramuscular fat of the fatteners, total cholesterol content increases as well (Tab. 2). LENARTOWICZ and KULISIEWICZ (1998), as well as DORADO et al. (1999), confirmed similar dependence. The progeny of hybrid boars Pi x D and D x Pi were characterised by higher level of cholesterol content in comparison with the progeny of Pietrain boars, respectively by 9% and 12%.

The hybrid boars of Duroc sire and Pietrain dam (group III) caused a significantly higher increase in the intramuscular fat, as well as in total meat cholesterol, of their offspring in comparison with reciprocal combination (group II). Comparing the influence of sire on fatty acids content in *m. longissimus dorsi* of their progeny (Tab. 3), one must state that D x Pi hybrid boars had the least favourable characteristics in this respect. The muscle of the progeny of D x Pi sire (group III), with the highest level of intramuscular fat, contained most SFAs and least UFAs, including PUFAs, in comparison with the fatteners of both remaining groups. It was demonstrated in the studies by other authors (EIKELENBOOM et al., 1996; LENARTOWICZ and KULISIEWICZ, 1998; DORADO et al. 1999; BIEDERMANN et al., 2000b) that, along with the growth in intramuscular fat content, the content of SFAs increased, whereas the content of PUFAs decreased. The composition of *m. longissimus dorsi* fatty acids of the progeny of Pi x D boars (group II) and Pietrain boars (group I) was similar, despite the fact that intramuscular fat contents was higher ($P \leq 0.01$) by about 23% in the muscle of fatteners of group II in comparison with fatteners of group I. CAMERON and ENSER (1991) stated that, along with the growth in meat intramuscular fat, the content of SFAs increased, while the content of PUFAs decreased. However, the degree of these changes depends on the breed of pigs. In the studies by some authors (KELLOG et al., 1977; LENARTOWICZ and KULISIEWICZ, 1998; LAACK and SPENCER, 1999), it was demonstrated that fatty acids content in pig meat is determined genetically. BIEDERMANN et al. (2000b) observed a relationship between the content of *m. longissimus dorsi* fatty acids in the Pietrain breed and the MHS genotype (NN, Np, pp). The authors reported the highest content of SFAs and MUFAs, and the lowest content of PUFAs, in the meat of the pigs with the NN genotype. On the other hand, the lowest content of SFAs and MUFAs, with the highest content of PUFAs, was observed in the muscle of the pigs with the pp genotype.

In the present studies, the gilts were characterised by better meatiness and contained less *m. longissimus dorsi* intramuscular fat and SFAs, but more PUFAs, in comparison with the barrows. It was also demonstrated in the studies by other authors that gilts were more fleshy, had less intramuscular fat (LENARTOWICZ and KULISIEWICZ, 1998; BAULAIN et al., 2000; BIEDERMANN et al., 2000a), less SFAs, and more PUFAs in *m. longissimus dorsi* (BIEDERMANN et al., 2000b) than the barrows.

Conclusion

1. The progeny of the hybrid boars Pi x D is characterised by lower intramuscular fat and cholesterol content and better fatty acids composition in *m. longissimus dorsi* in comparison with the progeny of the hybrids D x Pi. Therefore, fatteners production should be based on the hybrid boars with the Duroc breed in maternal position (Pi x D).
2. The gilts, in comparison with the barrows, are more meaty and their meat contains less intramuscular fat and of total cholesterol and, it is characterised as well of more favourable content of fatty acids.

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