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INVESTIGATIONS OF FACTORS INFLUENCING THE LEVEL OF SUBCUTANEOUS AND INTRAMUSCULAR FAT IN SWINE CARCASSES

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The authors determined the impact of carcass weight, genotype, sex, and nutrition on the degree of musculature and subcutaneous fattening as well as the level of intramuscular fat in fatteners obtained from market purchase. From among the examined weight groups, carcasses of heavy fatteners were characterized by poorer meatiness, thicker back fat and greater muscle fat content. The evaluation of the examined fattener genotypes revealed a significantly greater fattening of the muscles of crossbreds with 50% proportion of boars of the Duroc breed and purebred pigs than three- and four-breed fatteners obtained using Hampshire and Pietrain breeds. The investigations confirmed better musculature and lower fat content of gilts in comparison with hogs. Moreover, the performed experiments also showed a significant influence of traditional feeding on the reduction of meatiness and increased fattening in comparison with the animals which were fed Grower and Finisher mixtures.

INTRODUCTION

Actions which have been undertaken in Poland in recent years in swine breeding and production resulted in a considerable progress in the musculature of the domestic populations of swine. The selection work carried out in order to decrease carcass fattening led not only to the reduction of carcass fattening but also to the lower content of intramuscular fat [Różycki, 2005].

The level of intramuscular fat exerts a significant influence on meat organoleptic value which encouraged researchers to investigate its genetic background leading to attempts to identify and locate QTL genes in the swine genome which control the content of intramuscular fat. De Koning *et al*. [1999] showed (after Blicharski *et al*. [2004]) that the region of chromosome 7 as well as 2, 4 and 6 can contain genes controlling the level of intramuscular fat. Many methods can be found in the literature on the subject which allow to assess swine meat marbling. These methods include, among others: computer image analyses of the LD muscle [Faucitano *et al*., 2005], spectral analysis of ultrasounds [Mörlein *et al*., 2005] or measurements with the assistance of a spectroscope [Altmann & Pliquett, 2006].

In market purchase of pigs, majority of the obtained animals derive from the crossing of white breed sows with Duroc, Hampshire or Pietrain breed boars or their hybrids as well as different hybrid fatteners of varying degree of fattening and musculature. The results of their intramuscular fattening assessment are not fully recognized.

The fatteners is a result of body weight, genotypes, sex and other factors. In the literature we can find some reports in which was observed increase of fat thickness as increased weight of carcasses [Gardzińska *et al*., 2002; Zyber *et al*., 2001]. Moreover it was stated that in the muscles of heavier fatteners the level of intramuscular fat was higher than in the lighter pigs [Wajda *et al.,* 2004a; Koćwin-Podsiadła *et al*., 2002]. It is known also dependence of fatteners with sex, where usually the hogs characterized by thicker fat and higher content of intramuscular fat than female [Rybarczyk *et al*., 2005]. These observations usually obtained as a result of evaluation of experimental animals. A study results from fatteners of mass population as a complex influence of some factors affected at the same time on fatteners are not numerous.

The objective of this study was to determine the influence of the body weight, genotype and nutrition on the degree of musculature and subcutaneous fattening and the level of intramuscular fat in the muscles of fatteners selected from the market purchase.

MATERIAL AND METHODS

The experimental material comprised carcasses selected from several meat processing plants. Their choice was preceded by measurements of carcass fattening which comprised over 200 fatteners from the market purchase. Carcasses of the following groups were selected randomly: (a) four groups (50 carcasses each) weighing: group I – 70-80 kg; group II – 80.1-90 kg; group III – 90.1-100 kg and group IV – over 100 kg; (b) gilts and hogs of 100 animals each; (c) six swine genotypes in which the maternal component comprised gilts of white breeds (PLW x PL) mated with boars of Duroc (D – 88 carcasses), Hampshire (H – 84 carcasses) and Pietrain

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breeds (P – 52 carcasses) as well as their crossbreds: H x D, P x D, H x P (80 carcasses in each group). In addition, hybrid fatteners Naima x P-76 (n – 145) and PIC (n – 704) as well as fatteners derived from parents imported from Denmark in which the maternal line was Yorkshire x Landrace and paternal side – Hampshire x Duroc (Y x L) x (H x D) (n – 110) were also evaluated. The control group comprised purebred fatteners PLW x PLW (n – 50 carcasses); and (d) two groups of 80 carcasses each weighing approximately 103 kg were isolated which were derived from PLW x PL white fatteners which were fed using traditional feeds (grains, potatoes, slops) and Grower and Finisher mixtures which were raised in small farms.

Hot, hanging left half-carcasses of the examined population were used to determine meatiness with the assistance of the CGM optic-needle apparatus as well as the thickness of the back fat in 5 places of the carcass, *i.e.* on the back over the last rib, over the shoulder and on the ham in points KI, KII and KIII [Borzuta, 1998]. Thirty carcasses were selected from each of the examined groups (50 carcasses from each of the weight groups) and from these groups, the lumbar part of the *longissimus dorsi* (LD) muscle was excised with the aim to determine the content of the intramuscular fat using, for this purpose, the Soxhlet method [PN-73/A–8211].

The obtained results were elaborated statistically calculating means, standard deviations and the significance of differences between means of the examined groups with the assistance of the Tukey's test [Stanisz, 1998].

RESULTS AND DISCUSSION

Structural changes in the proportion of the breeds of fatteners have been observed for many years now in the mass population of pigs. The introduction of high meat breeds improved the meatiness of carcasses which was also accompanied by a simultaneous decrease of subcutaneous fat and intramuscular fattening [Karamucki *et al*., 2003; Koćwin-Podsiadła *et al*., 2003; Borzuta *et al*., 2003].

The results of the performed investigations revealed statistically significant differences between light and heavy fatteners with regard to carcass musculature and fattening (Table 1). Similar meat content was found in groups I to III (53.76 to 54.28%), while in the carcasses weighing more than 100 kg, the meat content was by 6% lower. A trend for increased carcass meatiness together with the decrease of their weight was also corroborated by other researchers [Łyczyński *et al*., 2000; Zybert *et al*., 2001; Kortz *et al.,* 2003; Wajda *et al*., 2004b]. However, some researchers reported that the selection of appropriate swine genotypes makes it possible to rear pigs to higher body weights without reducing their meatiness [Koćwin-Podsiadła *et al*., 2002; Przybylski *et al*., 2005].

The analysis of the degree of fattening of the examined weight groups revealed a significantly thicker back fat in all the estimated points in carcasses heavier than 100 kg in comparison with the remaining groups (Table 1). Back fat thickness on the ham in points KI, KII and KIII was found similar in the first three groups. The back fat thickness from 5 measurements was similar in carcasses weighing 70-80 kg and 80.1-90 kg, while in the heavier group of carcasses weighing over 100 kg the back fat was over 10 mm thicker. Increased back fat thickness, together with the increase of the carcass weight, was also reported by other researchers [Zyber *et al*., 2001; Łyczyński *et al*., 2000; Migdał *et al*., 1999; Gardzińska *et al.,* 2002].

Migdał *et al.* [1999] maintains that, in experiments carried out by Weatherup *et al*. [1997] and Ellisa & Avery [1990] on swine synthetic lines and hybrids, it was possible to produce high quality carcasses even when pigs were slaughtered at the highest body weight. The results obtained by them indicate that the weight of slaughtered fatteners may depend on the crossing design and the applied breeds.

The experimental carcass groups were also analysed from the point of view of their intramuscular fattening (Table 1). The lowest content of this fat (1.91%) was recorded in the LD muscles of fatteners with the carcass weight of 70 to 80 kg. In consecutive groups, the authors observed growing muscle

TABLE 1. Characteristics of slaughter value and meat quality of fatteners with different slaughter weight.

Specification	Group of fatteners				SEM
	I	II	III	IV	
	70.0 – 80.0 (kg)	80.1 – 90.0 (kg)	90.1 – 100.0 (kg)	> 100.0 (kg)	
	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	
Hot carcass weight (kg)	76.61	85.68	95.21	103.34	3.89
Meat content in carcass (%)	53.95^{A}	54.28^{A}	53.76^{A}	48.36^{B}	4.59
Backfat thickness (mm):					
– over shoulder	36.90^{Aa}	38.06^{AB}	40.90^{Bb}	48.15^{C}	7.16
– on back	20.08^{A}	21.92^{A}	25.18^{C}	29.15^{D}	4.86
– on cross I	27.60^{A}	28.45^{A}	30.45^{A}	38.41^{B}	7.12
– on cross II	18.04^{A}	17.57^{A}	18.80^{A}	27.25^{B}	6.44
– on cross III	25.88^{A}	25.45^{A}	27.23^{A}	37.22^{B}	8.29
Mean value (5) of backfat thickness (mm)	25.70^{A}	26.29^{AB}	28.51^{B}	36.03^{C}	6.61
Intramuscular m.LD fat content (%)	1.91^{A}	2.31^{B}	2.37^{B}	2.67^{B}	0.82
Marbling m. LD (points)	2.36	2.47	2.42	2.57	0.60

A,B,C,D – differences significant at $p \leq 0.01$; a, b – differences significant at $p \leq 0.05$

fattening together with the increase in the weight of carcasses (from 2.31 to 2.67% of fat) and the determined fattening level differed significantly in comparison with lighter carcasses (group I). The above-mentioned observations are corroborated by investigations carried out by other authors who also reported higher fat level contents in the muscles of heavier fatteners in comparison with the lighter animals [Wajda *et al*., 2004c; Koćwin-Podsiadła *et al*., 2002].

Another experimental factor examined in the trial was the impact of genotype on the fattening of the examined carcasses. The examined population of swine genotypes selected from the mass population was characterized by a similar weight (from about 75 to about 80 kg), although it differed with regard to the extent of the carcass musculature and fattening (Table 2).

In comparison with the fatteners from the control group (PLW x PLW), the carcasses from the assessed crosses were characterized by approximately 1.5 to 5.6% more meat. In the case of fatteners after Hampshire and Pietrain boars (groups H, P and HD) as well as in (Y x L) x (H x D) hybrids, the content of meat in carcasses was assessed at approximately 55%, whereas in the case of crosses with the addition of 50% of Duroc blood (group D) the meat content dropped by about 3%. The above observations were also corroborated by the results of other researchers who investigated crossbreds of similar crossing scheme and applied breeds [Buczyński *et al*., 1996; Jasek *et al*., 1998; Ksobiak *et al*., 2005].

The performed evaluation of the examined genetic groups confirmed that the selection carried out in swine breeding led to increased carcass meatiness accompanied by simultaneous reductions in the levels of subcutaneous, inter- and intramuscular fat [Karamucki *et al*., 2003; Migdał *et al*., 2004; Blicharski *et al.,* 2004]. In this study, the mean back fat thickness from 5 measurements in the examined groups ranged from 22 mm (group H) to 28.5 mm (group K). In the carcasses of fatteners with meatiness of about 55%, the back fat on the ham (point KII) was significantly thinner (from 14.4 mm to 17 mm) in comparison with fatteners with poorer musculature (group D – 18.2 mm and PD – 19.1 mm). In the case of purebred fatteners, the thickest back fat in all the examined points on the carcass was recorded at the lowest meatiness in relation to the remaining groups (KII – 27.1 mm). With regard to the analyzed crosses, the highest fat content was determined in the meat of white breed swine most mated with the Duroc breed (group D – 4.79%). The obtained results indicate that pigs of Duroc breed retained their capability of depositing higher quantities of fat in their muscles. This fact was also confirmed by experiments carried out by other researchers [Jasek *et al*., 2002].

Similar muscle fattening was found in purebred fatteners and in the crosses upgraded with the Hampshire breed (groups H and HD) (3.36, 3.45 and 3.25% fat, respectively) accompanied by differing meat content in the carcasses of these animals. On the other hand, the meat of fatteners upgraded with Pietrain boars was found to contain lower fat levels (from 2.12 to 2.38%). Gajewczyk [2005] reported fat levels by about 0.3% higher in the meat of similar genetic groups upgraded by the Pietrain breed.

The organoleptic value of pork meat is influenced significantly by intramuscular fat. The importance of intramuscular fat triggered out investigations aiming at determining its genetic preconditioning. Opinions were circulated that the correlation between the back fat thickness and the content of intramuscular fat was less obvious than it was widely believed. Low interrelationships obtained in this study as well as reports from other researchers [Wajda *et al*., 2004; Rybarczyk *et al.,* 2005] corroborate the above opinions. The correlation coefficients determined in this study between the content of intramuscular fat and the back fat thickness on the back as well as on the ham at point KII amounted to: $r = 0.34$ and $r = 0.37$, respectively.

The most recent investigations indicate that it is possible that there is one main gene which controls the content of intramuscular fat. In the case of homozygote meat with a hypothetic MI^+ gene, the content of intramuscular fat was determined at the level of 3.9% in comparison with the level of 1.8% found in the meat of animals free from this gene [Blicharski *et al.,* 2004].

TABLE 2. Results of carcass slaughter value with different genotype of fatteners.

Groups	Hot carcass weight (kg)	Meat content in carcass (%)	Thickness of fat (mm)				Intramuscular fat of m. LD (%)
			over shoulder	on back	on cross II	mean of 5 measurement	
PLW x PLW	75.83 ^{A}	50.66 ^{A}	38.57 ^{A}	24.03 ^{A}	27.10 ^{A}	28.48 ^{A}	3.36 ^{B}
(PLW x PL) x D	74.74 ^{A}	52.09 ^{Ba}	35.63 ^{Ba}	21.47 ^{Ba}	18.27 ^{B}	25.43 ^{B}	4.79 ^{A}
(PLW x PL) x (H x D)	74.94 ^{A}	55.25 ^{C}	33.77 ^{Cb}	22.97 ^{Ab}	17.00 ^{B}	24.36 ^{B}	3.25 ^{Bb}
(PLW x PL)x H	73.75 ^{B}	56.28 ^{C}	31.43 ^{c}	19.43 ^{C}	14.40 ^{C}	21.4 ^{Ca}	3.45 ^{B}
(PLW x PL) x P	81.31 ^{C}	54.68 ^{D}	36.61 ^{AB}	22.31 ^{A}	14.94 ^{C}	24.20 ^{B}	2.25 ^{C}
(PLW x PL) x (P x D)	79.67 ^{C}	53.42 ^{b}	37.22 ^{A}	22.55 ^{A}	19.12 ^{B}	26.0 ^{B}	2.12 ^{C}
(PLW x PL) x (H x P)	80.30 ^{C}	55.27 ^{C}	29.90 ^{d}	17.90 ^{D}	15.10 ^{C}	20.52 ^{b}	2.38 ^{C}
(Y x L) x (H x D)	81.29 ^{C}	55.18 ^{C}	33.61 ^{C}	19.79 ^{C}	15.05 ^{C}	23.46 ^{B}	2.46 ^{Ca}
Naima x P-76	79.61 ^{C}	54.01 ^{D}	34.96 ^{B}	19.53 ^{C}	15.84 ^{C}	23.64 ^{Bc}	2.43 ^{Ca}
PIC	80.53 ^{C}	53.18 ^{b}	38.20 ^{A}	24.31 ^{A}	15.12 ^{C}	25.98 ^{Bd}	2.89 ^{Db}
S.E.M.	3.85	4.09	4.95	4.39	4.60	4.55	0.67

a,b,c,d – differences significant at $p \leq 0.05$; A,B,C,D – differences significant at $p \leq 0.01$

Another experiment which was carried out within the framework of this study was focused on the determination of differences occurring in the fattening and musculature between carcasses of gilts and hogs derived from swine mass population (Table 3).

Approximately 2.72% more meat was recorded in the carcasses of gilts, whereas in hogs – back fat was found significantly thicker in all the measured points on the carcass. Literature data confirm better musculature and worse fattening of gilt carcasses in comparison with hog carcasses [Bąk *et al*., 2003; Karamucki *et al*., 2003; Rybarczyk *et al*., 2005]. Bearing in mind the observed differences between sex with regard to the meat content and the subcutaneous fat thickness, some researchers have suggested a separate rearing of gilts and hogs [Bąk *et al*., 2003]. Eckert [2000] maintains that it is possible to achieve higher meatiness of hogs at lower slaughter weight or by rearing them to about 100 kg body weight introducing restrictive feeding during the period immediately before slaughter. Analyzing the intramuscular fattening between sex, the authors also demonstrated a significantly higher (by 0.34%) fat content in the meat of hogs. Similar differences between sex were also reported in a study by Krzęcio *et al*. [2004]. On the other hand, Rybarczyk *et al*. [2005] analysed different muscle fattening in carcasses and failed to find significant differences in the fat content in the LD muscle between gilts and hogs.

It is commonly known that the carcass quality of fatteners depends to a considerable extent on the way of nutrition. It was proved that the kind, quantity and quality of protein in the feed all exert influence on the carcass slaughter value, especially on the chemical composition and physico-chemical properties of pork meat [Weisemüller, 1996; Fendrejewski *et al*., 1996]. Taking into consideration the above observations, the authors investigated in this part of the study the impact of the kind of feed employed in the performed experiments on the extent of musculature and fattening of heavy fatteners of white breeds. It was found that carcasses of fatteners fed traditional feeds were characterised by 4.62% less meat and by about 4 mm thicker back fat over the shoulder and on the ham at point KII in comparison with fatteners fed Grower and Finisher mixtures. On the other hand, no significant differences were found between the discussed two groups with regard to intramuscular fattening.

When analysing the above presented results, it was quite interesting to find that the determined correlations between the content of intramuscular fat and back fat thickness were relatively low (r = about 0.3). Absence of the influence of the subcutaneous fattening on the degree of intramuscular fattening was also reported by Łyczyński *et al*. [2004]. The above observations appear to corroborate the assumption that the content of intramuscular fat is controlled by other genes than those which control the thickness of back fat [Schwägele 2001; Blicharski *et al*., 2004].

CONCLUSIONS

Recapitulating the above-described investigations it can be said that it was shown that from among the examined weight groups, heavy carcasses with the weight of over 100 kg were characterized by lower meatiness, thicker back fat at all the measured points as well as greater intramuscular fattening of muscles in comparison with lighter carcasses.

The performed assessment of the examined genotypes of fatteners revealed a significantly higher muscle fattening of crossbreds with a 50% upgrade by the Duroc breed boars as well as purebred fatteners in comparison with three- and four-breed hybrids upgraded by the Pietrain and Hampshire breeds.

The performed experiments further confirmed better musculature as well as greater subcutaneous fat content and intramuscular fattening of gilt carcasses than those of hogs.

It was also found that in comparison with the feeding using complete feed mixtures, the system which employed traditional feeding was found to exert a significant influence on the decrease of musculature and increase of fattening of the examined animals.

TABLE 3. Characteristics of slaughter value of fatteners with different sex and fattening.

Specification	Sex				Fattening			
	gilts		barrows		traditional		feed mixtures	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Hot carcass weight (kg)	82.51	2.85	81.10	3.20	103.50	5.91	102.71	6.72
Meat content in carcass (%)	54.41^{A}	4.75	51.69^{B}	5.14	46.48^{A}	4.45	51.10^{B}	4.90
Backfat thickness (mm):								
– over shoulder	37.72^{A}	6.48	41.30^{B}	7.29	50.76^{A}	8.80	46.85^{B}	7.13
– on back	21.91^{A}	5.74	25.32^{B}	5.45	29.09	8.45	27.52	6.45
– on cross I	28.85^{A}	6.89	32.54^{B}	7.10	38.35	8.39	36.04	7.25
– on cross II	18.57^{a}	6.49	20.69^{b}	6.75	29.94^{A}	7.97	25.84^{B}	6.34
– on cross III	25.89^{A}	7.66	31.27^{B}	7.77	37.54	10.53	38.48	8.07
Mean value of backfat thickness in 5 points (mm)	27.19^{A}	6. 60	30.22^{B}	7.19	37.12^{A}	8.82	34.94^{B}	7.05
Intramuscular m LD fat content(%)	1.99^{A}	0.76	2.33^{B}	0.80	3.10	0.56	2.85	0.75
Marbling m. LD (points)	2.39	0.56	2.46	0.61	2.95	0.47	2.58	0.79

A,B – significant at $p \leq 0.01$; a,b – significant at $p < 0.05$

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BADANIE CZYNNIKÓW KSZTAŁTUJĄCYCH POZIOM TŁUSZCZU PODSKÓRNEGO ORAZ ŚRÓDMIĘŚNIOWEGO W TUSZACH WIEPRZOWYCH

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Określono wpływ masy tusz, genotypu, płci i żywienia na stopień umięśnienia i otłuszczenia podskórnego tusz oraz poziom tłuszczu śródmięśniowego w mięśniach tuczników ze skupu rynkowego. Spośród badanych grup wagowych tusze tuczników ciężkich charakteryzowały się niższą mięsnością, grubszą słoniną i większym przetłuszczeniem mięśni. Ocena badanych genotypów tuczników wykazała istotnie większe przetłuszczenie mięśni mieszańców z 50% udziałem knurów rasy duroc i świń czystorasowych niż u tuczników trój i czterorasowych z udziałem rasy hampshire i pietrain. Potwierdzono lepsze umięśnienie i mniejsze otłuszczenie tusz loszek w porównaniu z wieprzkami. Wykazano istotny wpływ żywienia tradycyjnego na obniżenie mięsności i większe otłuszczenie tusz w stosunku do osobników żywionych mieszanką paszową Grover i Finiszer.