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CHARACTERISTICS OF THE POLISH BREEDING POPULATION OF PIGS IN TERMS OF INTRAMUSCULAR FAT (IMF) CONTENT OF *M. LONGISSIMUS DORSI**

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Abstract

Subjects were Polish Landrace (PL), Polish Large White (PLW), Puławska, Hampshire, Duroc, Pietrain and line 990 gilts tested in the Polish Pig Performance Testing Stations (SKURTCh). A total of 4430 animals were investigated. During the test, animals were kept individually and fed *ad libitum*. Intramuscular fat (IMF) content was determined as crude fat by Soxhlet extraction with fat solvents (Soxtherm SOX 406, Gerhardt). Samples for analysis were taken from the middle cross-sectional area of *m. longissimus dorsi* behind the last rib. The highest level of IMF was observed for Duroc animals (2.23%) and the lowest for the Pietrain breed (1.66%). In the two most popular breeds in Poland (PLW and PL), this parameter was below the level acceptable for good quality meat (1.84% and 1.76%, respectively). IMF content of *m. longissimus dorsi* showed high variation ranging from V = 27.8% to V = 41.8% according to the breed.

Key words: pigs, population, intramuscular fat, *longissimus* muscle

High carcass lean content has been one of the main targets of pig breeders for many years. Because it is highly important to both breeders and the meat industry from the economic viewpoint, breeding work has focused on improving the Polish breeding population of pigs. As a consequence, much better carcass muscling was obtained to the detriment of meat quality. This was due to a negative relationship between lean content and meat quality traits and resulted in the appearance of several meat defects affecting processing technology, thus impinging on the economics of fattening pig production.

Meat quality is not easy to define and depends on many factors (Sellier and Monin, 1994). One of the characteristics used to determine this parameter are sensory traits, including the associated intramuscular fat (IMF) content. One-sided selection

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had an adverse effect on lean content in the form of poorer taste of pork and pork products, which was strictly related to the IMF content. Most researchers investigating meat quality report that the IMF content of good quality meat should range from 2% to 3% (Ellis, 2006; Wood et al., 1998). It should be noted that this fat is a carrier of taste while having a beneficial effect on meat tenderness, palatability and juiciness (Enser, 2004). It also reduces thermal loss during cooking and grilling because increased fat has a positive effect on the water holding capacity of meat.

The most efficient way of increasing the level of chosen productive traits is to use accurate methods of assessment. In Poland, muscling and meat quality in breeding animals are assessed at Pig Performance Testing Stations (SKURTCh). This evaluation makes it possible to determine slaughter value and meat quality in selected barrows and gilts based on carcass dissection of their full sibs, and in the case of boars currently used in herds, based on dissection results of their offspring (Różycki and Tyra, 2009). In 2007, the measurement of IMF content of *m. longissimus dorsi* was included in the station test for animals completing the test. The inclusion of meat quality traits next to fattening and slaughter traits in the assessment and in breeding programmes will improve these parameters in the breeding population and thus in the whole population producing fattening pigs. For these changes to be made to the current breeding programme, it is necessary to determine trends in the IMF content of the population being improved. Therefore, we conducted this study to determine this parameter for all breeds raised in Poland.

Material and methods

Subjects were Polish Landrace (PL), Polish Large White (PLW), Puławska, Hampshire, Duroc, Pietrain and line 990 gilts tested in the Polish Pig Performance Testing Stations (SKURTCh) in Chorzelów, Mełno, Pawłowice and Rossocha. We studied 4430 gilts tested in 2007–2009, including 1240 PLW, 2083 PL, 104 Puławska, 35 Hampshire, 152 Duroc, 208 Pietrain and 608 line 990. During the test, animals were kept and fed individually.

The actual test began when animals reached 30 kg body weight and ended at a final weight of 100 kg. Feed intake was recorded throughout the test. Two feed mixtures were used during this period. The first, given to animals weighing 30 to 80 kg, contained 13.50 MJ/kg energy and 17–19% crude protein. The second, used between 80 and 100 kg body weight, contained 13 MJ/kg energy and 16–18% crude protein.

Animals were slaughtered at 100 kg body weight and right half-carcasses were dissected after 24 h chilling. Carcass lean percentage was calculated from a regression equation using dissection data.

IMF content of meat was determined as crude fat by Soxhlet extraction (PN-ISO 1444:2000) with fat solvents (Soxtherm SOX 406, Gerhardt). The Soxhlet method, used in this device, provides for highly accurate measurements with considerably shorter extraction time. Samples for analysis were taken from the middle cross-sectional area of *m. longissimus dorsi* behind the last rib.

Calculations were made for each breed separately. Statistical analysis was performed by analysis of variance using the GLM procedure of SAS (1989). The statistical model used for the calculations was as follows:

$$Y_{ijkl} = \mu + d_i + f_j + \alpha(x_{ijk}) + e_{ijkl}$$

where:
y_{ijkl} – $ijkl^{th}$ observation,
μ – overall mean,
d_i – effect of i^{th} test station,
f_j – effect of j^{th} sire,
$\alpha(x_{ijk})$ – covariance on right half-carcass weight (for slaughter traits and IMF),
e_{ijkl} – random error.

Differences between the means for individual breeds were tested at 5% and 1% levels using Duncan's multiple range test.

Results

Table 1 shows data for fattening and slaughter value of the pigs studied. The table encompasses means and standard deviations for traits included in the selection index, calculated for animals completing the station test (daily gain, weight of ham without backfat and skin, mean backfat thickness from 5 measurements, loin eye area), as well as data on carcass lean percentage and feed conversion per kg gain. Analysis of these data shows that gilts of the two most popular breeds in Poland (PLW and PL) achieve similar levels of the above traits. Animals of both breeds are characterized by very good rate of growth (daily gains of 890 g in the test) and good slaughter parameters (lean content of 58%, loin eye area around 53 cm^2).

Pietrain gilts had the highest carcass lean content, the heaviest ham, the largest loin eye area and the lowest backfat thickness (average of 5 measurements) of all breeds under study. However, the Pietrain breed considerably differed from most other breeds analysed in terms of growth rate and feed conversion per kg gain. Only Puławska gilts were inferior in this respect. For lean content traits, Duroc fell in between the Pietrain breed and PLW and PL breeds. Characteristically, although Duroc animals had thicker backfat, they surpassed PLW and PL breeds in carcass lean percentage. A different pattern was observed for the Pietrain breed, which had better muscling and thinner backfat compared to PLW and PL breeds.

In all the breeds, backfat thickness (average of 5 measurements) showed highest variation (over 20%) of all traits analysed. For lean content traits (carcass lean percentage and weight of ham without backfat and skin), variation in the analysed breeds did not exceed 8%.

Table 1. Mean results and standard deviations (SD) for selected traits of animals on test

Analysed traits		Breed						
		PLW	PL	Puławska	Hamp-shire	Duroc	Pietrain	Line 990
No. of animals	n	1240	2083	104	35	152	208	608
Daily gain, 30 to 100 kg b.w. (g)		896	894	780	971	941	830	891
		130	121	64	110	122	106	77
Feed conversion per kg weight gain (kg)		2.81	2.83	3.19	2.71	2.80	2.95	2.75
		0.36	0.38	0.31	0.41	0.34	0.37	0.32
Backfat thickness (av. 5 measurements) (cm)		1.52	1.42	1.92	1.79	1.67	1.23	1.83
		0.37	0.35	0.32	0.27	0.32	0.33	0.34
Loin eye area (cm^2)		52.7	53.4	48.6	54.0	50.5	62.5	56.1
		6.35	6.47	4.84	7.25	6.03	7.90	6.20
Weight of ham without backfat and skin (kg)		8.86	8.79	8.29	8.94	9.05	10.1	9.10
		0.65	0.63	0.56	0.68	0.52	0.63	0.55
Carcass lean content (%)		58.7	58.9	55.1	59.6	59.6	66.2	59.8
		3.23	3.22	2.89	3.24	2.74	3.10	2.71

Table 2 presents basic data for IMF content in breeds raised in Poland. Based on these data, the pig population analysed can be divided into two groups. The first group are the breeds with IMF content falling within the range considered appropriate by many authors, while the second group includes those with IMF below the level acceptable for good quality meat. The first group includes Duroc and Puławska pigs. The mean IMF content of *m. longissimus dorsi* (2.23% in Duroc and 2.17% in Puławska) differed significantly from that of the other breeds.

Table 2. Means, standard deviations, coefficients of variation, minimum and maximum values for intramuscular fat (IMF) content of *m. longissimus dorsi* in pigs raised in Poland

Breeds	x		δ	V (%)	Min	Max
PLW	1.84	DImn	0.69	37.5	0.38	4.01
PL	1.76	CHop	0.66	37.4	0.29	4.17
Puławska	2.17	FGHIJ	0.60	27.8	1.34	4.40
Hampshire	1.71	BGlnp	0.71	41.8	0.66	3.82
Duroc	2.23	ABCDE	0.67	30.4	0.89	4.36
Pietrain	1.68	AFkmo	0.64	37.8	0.37	3.46
Line 900	1.91	EJkl	0.73	38.4	0.60	3.86

The second group are animals characterized by IMF content below 2% (PL, PLW, line 990, Hampshire and Pietrain). It should be noted that IMF values differed among the breeds within this group. PLW, PL and line 990 gilts achieved higher means that were significantly different from those of Pietrain and Hampshire gilts.

Discussion

Analysis of the data for performance tests of the gilts (Eckert and Szyndler-Nędza, 2009), which provides a survey of the entire active population, showed that the breed structure was identical to that observed in our study. Values of traits obtained from these tests were also consistent with our results. Literature data indicate that IMF content should exceed 2% to obtain good quality pork (Wood, 1998). Recent problems with decreasing IMF content of meat are faced by those European countries whose breeders strived to achieve rapid increases in carcass lean content. In the early 1990s, this mainly concerned the Pietrain breed (Meyer, 1991). A similar trend was observed in Poland. When analysing data on IMF content in hybrids derived from the crossing of different breeds, Lenartowicz and Kulisiewicz (1998) found IMF to be the lowest in pigs sired by Pietrain boars. By way of comparison, PLW and PL pigs raised during the same period were characterized by higher IMF (4.10% and 2.94%, respectively), sometimes much in excess of permissible standards (Różycki et al., 1997). This problem does not exist in local (conservation) breeds subjected to no selection pressure for lean content. For Bisaro and Alentejano breeds, Silva et al. (2000) found high IMF levels of 2.64% and 4.05%, compared to 0.84% found for Landrace and Large White crossbreds investigated in the same study.

A study by Florkowski et al. (2006), who compared native breeds (Puławska and Złotnicka Spotted) with Polish Landrace, showed that the level of analysed fat in these two breeds was over twice that of Polish Landrace animals (Puławska – 2.5%, Złotnicka Spotted – 3.1%, Polish Landrace – 1.3%). In our study, we also observed predominance of the Puławska breed over Złotnicka Spotted and Polish Landrace breeds, but the results are slightly different from those presented above, especially with regard to Polish Landrace. It should be noted, however, that the above authors analysed a relatively small number of animals (18 animals of each breed studied), which is not a very representative sample, especially as regards the Polish Landrace breed.

The white breeds (PLW and PL) currently raised in Poland are characterized by low IMF content that is below the required level. This concerns both the breeding population, as evidenced by our results, and data from meat processing plants concerning the commercial population (Daszkiewicz et al., 2005). Research conducted in 2004-2006 with the domestic population of pigs indicated that IMF was 1.89% in the most popular breed (PL) and 2.43% in the conservation breed Puławska (Tyra and Orzechowska, 2006). This meant that by that time, IMF level was not high enough (especially in the PL breed) to conclude that the meat of domestic breeds is of desirable quality in the entire population. The above authors reported that only part of the population (PL), about 38%, had IMF content exceeding 2%, and thus had meat of good quality. Therefore, it seemed appropriate to improve this trait through selection. As shown by data from Table 3, no such efforts were made at that time. The current breeding population falls short of good meat quality standards in terms of IMF content, especially in PLW and PL breeds.

Table 3. Number and percentage of animals in different ranges of intramuscular fat (IMF) content

Breed	IMF groups					
	below 2%		2% to 3%		above 3%	
	n	%	n	%	n	%
PLW	797	64.0	363	29.1	86	6.9
PL	1448	69.5	492	23.6	143	6.9
Puławska	54	51.9	40	38.5	10	9.6
Hampshire	24	68.6	9	25.7	2	5.7
Duroc	55	36.2	75	49.3	22	14.5
Pietrain	150	72.1	47	22.6	11	5.3
Line 900	370	60.9	171	28.1	67	11.0

When analysing current data on the distribution of animals of different breeds depending on IMF group (Table 3), it was found that the proportion of pigs with desirable IMF parameters was 30% for PLW and just 23% for PL animals. These data illustrate the rate of unfavourable changes that occurred in this trait among PLW and PL breeds. It is pertinent to note that some animals are characterized by IMF levels above 3–3.5%, which Fernandez et al. (1999) state is the upper permissible limit of intramuscular fat accepted by consumers while having no negative impact on fat processing technology. Analysis of Table 3 showed that this trait was below 2% in most PLW and PL animals (64.0% and 69.5%, respectively). The Duroc breed presented a slightly better situation, with almost 50% of animals showing favourable IMF levels. The analysis of the investigated animals for intramuscular fat content (Table 2) revealed that a considerable proportion of animals meet the requirement for good quality meat. At the same time, the high variation of this trait could guarantee an adequately high selection differential, which offers hope for improvement of this parameter. In addition, it would be necessary to find relationships between selection traits used in the current breeding programme and IMF. If no antagonistic relationships are found, this parameter should be included in the updated breeding programme, following the example of other European countries.

Positive results towards improving IMF content could be attained by appropriate crossbreeding, but the base breeds used for this purpose should be characterized by good parameters of this trait. This is confirmed by the findings of Jacyno et al. (2002), who showed that the crosses of these breeds (Duroc × Pietrain and Pietrain × Duroc) achieved much higher IMF values compared to purebred Pietrains. Similar relationships for the crossbreds of this breed were also observed by Peloso et al. (2010) and Alonso et al. (2009). These breed combinations are drawing increased interest, as evidenced by the annually increasing number of performance-tested barrows. Similar observations emerge from the analysis of pig insemination data (Mucha and Tyra, 2009), according to which over 16% of all inseminations are performed using the semen of Duroc × Pietrain boars.

IMF levels can be influenced to a small extent by non-genetic factors such as duration of the fattening period. It should also be noted that increased final weight may decrease other sensory parameters such as meat tenderness (Candek-Potokar et al., 1998). Increased amount of subcutaneous fat can be another adverse consequence (Heyer and Lebret, 2007). The level of intramuscular fat can be regulated to a certain extent by nutrition. However, no significant improvements should be expected because this factor affects fat composition (fatty acid profile), which was reported by many authors (Scheeder, 2004; De Smet et al., 2004).

The breed differences found for fatness, muscling and growth rate traits as well as the antagonism observed in some breeds (Duroc) between these traits and IMF content may suggest breed specificity resulting from genetic factors. It seems, however, that efforts to obtain genetic material should focus mainly on genetic improvement of pigs to be able to produce animals characterized by appropriate amounts of meat in good quality carcasses. The observed high heritability of IMF (Newcon et al., 2005) is an argument for broadening the research to find a genetic factor that determines this trait. This idea is also supported by the findings of other authors (Damon et al., 2006; Gerbens et al., 2001; Urban et al., 2002) who used molecular genetic techniques (PCR/RFLP) to analyse mutational changes within *H-FABP* and *A-FABP* genes, which code for proteins involved in the binding and transport of fatty acids.

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Charakterystyka krajowej populacji zarodowej świń pod względem zawartości tłuszczu śródmięśniowego (IMF) w mięśniu najdłuższym grzbietu

STRESZCZENIE

Materiał do badań stanowiły loszki ras: pbz, wbp, puławskiej, Hampshire, Duroc, Pietrain i linii 990, oceniane w Stacjach Kontroli Użytkowości Rzeźnej Trzody Chlewnej (SKURTCh). Łącznie badaniami objęto 4430 zwierząt. W czasie testu zwierzęta były utrzymywane i żywione zgodnie z obowiązującą metodyka stacji kontroli. Zawartość tłuszczu śródmięśniowego (IMF) oznaczano jako tzw. tłuszcz surowy metodą Soxhleta przez ekstrakcję rozpuszczalnikami tłuszczowymi w urządzeniu SOXTHERM SOX 406 firmy Gerhardt. Próbkę do analiz pobierano ze środkowej części przekroju mięśnia najdłuższego grzbietu za ostatnim żebrem.

Najwyższy poziom badanego wskaźnika (IMF) obserwowano u zwierząt rasy Duroc (2,23%), a najniższy u rasy Pietrain (1,66%). Dwie najliczniej hodowane w kraju rasy, czyli wbp i pbz uzyskały ten parametr poniżej progu mięsa dobrej jakości odpowiednio 1,84% i 1,76%. Zawartość tłuszczu śródmięśniowego w mięśniu najdłuższym grzbietu charakteryzowała się wysoką zmiennością wynoszącą w zależności od rasy od V = 27,8% do V = 41,8%, co stanowi pozytywną informację dającą możliwość szybkiej poprawy tej cechy.