

Microstructure traits of *longissimus lumborum* muscle in Polish Landrace and crossbred Stamboek and Torhyb pigs

Joanna Bogucka¹, Wojciech Kapelański²

¹ Division of Animal Histology, University of Technology and Agriculture, Mazowiecka 28, 85-084 Bydgoszcz, Poland

² Department of Pig Breeding, University of Technology and Agriculture, Mazowiecka 28, 85-084 Bydgoszcz, Poland

(Received August 22, 2004; accepted October 8, 2004)

Material consisted of 98 castrated males of Polish Landrace (PL), and crossbreds from Dutch Stamboek (S) and Polish Torhyb (T) crossing programmes. The samples of *Longissimus lumborum* were frozen in liquid nitrogen. Microscopic preparations were subjected to a histochemical reaction to differentiate the types of muscle fibres varying in enzymatic activity. Proportion of each muscle fibre type was determined. Fibre diameters were also measured using the Q 500 MC Leica Image Analysis System.

Proportions of muscle fibre types were similar in all three groups. Proportion of STO fibres ranged from 13.42 (in T) to 14.90% (in PL). The highest number of FTO (18.50%) and the least of FTG fibres (68.08%) were observed in T crossbreds. The least share of FTO fibres (16.00%) and the highest of FTG fibres (70.50%) were shown in S pigs. S pigs had the least diameters of all muscle fibre types (STO – 43.12, FTO – 37.76 and FTG – 49.90 μm) and the highest number of all fibres on the surface of 1.089 mm^2 (230.50). The most beneficial pH_i value (6.41) and WHC (19.78%) were shown in S pigs. Better traits of meat quality were related to fine-fibre structure of *longissimus lumborum*.

KEY WORDS: microstructure / muscle / pigs

Modern pig breeding is currently directed at improving the meat content of carcass and meat quality. Certain hopes for the clarification of increased pig meatiness and decreasing meat quality are pinned on the studies of muscle tissue microstructure. The relations between enzymatic activity of individual types of muscle fibres, their

mutual proportions in the muscle and meat quality traits of pigs were the object of many studies [Kłosowska *et al.* 1998, 2002, Larzul *et al.* 1997, Henckel *et al.* 1997, Čandek-Potokar *et al.* 1999].

The aim of the present study was to assess the microstructure of *longissimus lumborum* muscle in purebred Polish Landrace pigs and in crossbreeds derived from specialized programmes (the Dutch Stamboek and the Polish Torhyb) with regard to some fattening, slaughter and meat quality traits.

Material and methods

The study was carried out with 98 castrated males of about 105 kg body weight, representing the following three groups:

- pure Polish Landrace (PL, n=20);
- Stamboek crossbreeds (S, n=39);
- Torhyb crossbreeds (T, n=39).

Within the Stamboek programme, two-breed crossing of maternal lines (Landrace) and of maternal and paternal lines (Large White) was used, as follows:

female LW (maternal line) × male LW (maternal line)
↓
female F₁ × male LW (paternal line) → fattening

Within the Torhyb programme crossbreeds were obtained by three-breed simple crossing, as follows:

female PLW × male PL
↓
female F₁ × male Pietrain → fattening

All animals were kept under the same environmental conditions and fed *ad libitum* from automatic feeders.

Histological examinations were made on *Longissimus lumborum* (LL) muscle samples taken 45 min *post mortem* and immediately frozen in liquid nitrogen. After being transferred to Leica cryostat, the muscle samples were cut into 10 μm slides. This was followed by a combined reaction for activity of NADPH-TR (diaphorase) and myofibrillar ATP-ase to distinguish different types of muscle fibres [Wegner *et al.* 1993]: STO – slow twitch oxidative, FTO – fast twitch oxidative, FTG – fast twitch glycolytic. Percentages of different muscle fibre types, fibre diameters and number of fibres per 1.089 mm² were estimated using the Q 500 MC computer image analysis system by Leica.

About 45 minutes *post mortem* pH_i of muscle was determined with a portable pH-

meter (pH Pistole) equipped with a glass electrode (MATTHÄUS). Next day, after the carcasses were completely cooled, both carcass-sides were weighed separately and assessed for quality using measurements and EU dissection rules given by Walstra and Merkus [1996]. Based on detailed dissection of right carcass-side, meat contents of carcass and ham were determined. Backfat thickness was measured at 5 points (over the shoulder, between the last thoracic and first lumbar vertebra, and at sacrum at points I, II and III). The LL cross-section was outlined and its area was determined with a planimeter under laboratory conditions. During dissection, LL samples were taken to determine water holding capacity (WHC) according to Grau and Hamm [1952].

Data were analysed statistically using STATISTICA 5.5 PL software [2000].

Results and discussion

Values of fattening, slaughter and meat quality traits are given in Table 1.

Daily gain is the best indicator of fattening performance in pigs. In the present study, they were satisfactory and even high and ranged from 801 to 863 g. Their level

Table 1. Selected fattening, slaughter and meat quality traits across groups of pigs

Trait		Group		
		EL	Stamboek	Turkyb
Daily gain (g)	mean	863 ^a	823	801 ^b
	SD	94	88	112
Mean backfat thickness from 5 measurements (cm)	mean	2.56 ^a	2.25 ^b	2.43
	SD	0.40	0.39	0.52
Loin eye area (cm ²)	mean	40.9 ^b	42.3	44.3 ^a
	SD	5.9	4.5	4.8
Meat content of carcass (%)	mean	51.1 ^b	51.4 ^b	53.7 ^a
	SD	3.6	2.9	3.2
Meat content of ham (%)	mean	66.7 ^{a,b}	68.5 ^b	70.4 ^{a,a}
	SD	3.6	3.2	3.7
pH _i	mean	6.15 ^{bc}	6.41 ^{aa}	5.94 ^{ab}
	SD	0.34	0.34	0.29
Water holding capacity (% loose water)	mean	21.47 ^a	19.78 ^{bc}	22.18 ^{aa}
	SD	2.72	2.77	3.60

^{aa} Within rows means bearing different superscripts differ significantly at: small letters - P<0.05; capitals - P<0.01.

was similar, and in some cases exceeded the daily gain obtained at SKURTCh Pig Testing Stations [Bzowska *et al.*, 2003]. S pigs proved best in terms of backfat thickness (2.25 cm), although Blicharski and Ostrowski [1996] reported in S fatteners a slightly lower backfat thickness (2.06 cm). Differences between pig groups were also found when assessing their slaughter value. Best carcass muscling was characteristic of the T

fatteners which had the largest loin eye area (44.3 cm²), and the greatest meat content of ham (70.4%) and of the whole carcass (53.7%). The significantly least favourable results of these traits were obtained in PL pigs (40.9 cm², 66.7% and 51.1%, respectively). In the studies by Kapelański *et al.* [1998] Pietrain crossbreds showed a lower meat content of carcass (50.9%). Michalska *et al.* [2000] reported 49.16% meat in pigs with 50% share of Pietrain. Muscling of PL pigs was much lower than that indicated by Pig Testing Stations (SKURTCh) – Wyniki oceny [2003]. Of the meat quality traits, the most favourable pH₁ and WHC were characteristic of the S pigs, being indicative of their best meat quality. A pH₁ value of 6.41 is close to the results obtained earlier in S pigs by Blicharski and Ostrowski [1996]. The lowest pH₁ value was found in T pigs (5.94), which may also suggest good meat quality. Slightly higher pH₁ values in Pietrain crossbreds were obtained by Kapelański and Hammermeister [1999] and Michalska *et al.* [2000]. S pigs were characterized also by the most favourable WHC value (19.78%). The worst WHC was observed in T pigs (22.18%), possibly related to the looser structure of muscle fibres and thus to increased intracellular space, as reported by Kłosowska *et al.* [1995].

The results of histological analyses of the LL muscle are given in Table 2, and the characteristic microscopic images are shown in Photos 1, 2 and 3.

Percentage of individual muscle fibre types was similar in all pig groups. Differences between the groups were observed for diameter of muscle fibres and the number of fibres per unit area of 1.089 mm². S pigs had the lowest diameters of all fibre types

Table 2. Traits of *Longissimus lumborum* muscle microstructure across groups of pigs

Trait		Group			
		PL	Stamboek	Toitryb	
Share of fibres (%)	STO	mean	14.90	13.30	13.42
		SD	3.83	2.60	3.37
	FTO	mean	16.43	16.00	18.30
		SD	3.32	4.74	4.73
	FTG	mean	70.02	70.30	68.08
		SD	3.50	4.91	5.00
Fibre diameter (µm)	STO	mean	46.80 ^a	43.12 ^b	43.74 ^b
		SD	3.34	4.30	3.77
	FTO	mean	43.62 ^a	37.76 ^b	38.90 ^b
		SD	5.03	4.90	4.30
	FTG	mean	61.08 ^a	49.90 ^b	52.30 ^b
		SD	6.42	6.23	6.53
Number of fibres per 1.089 mm ² area	mean	178.03 ^b	230.30 ^a	187.20 ^b	
	SD	28.30	42.30	32.91	

^{ab} Within rows means bearing different superscripts differ significantly at: small letters – P<0.05; capitals – P<0.01.

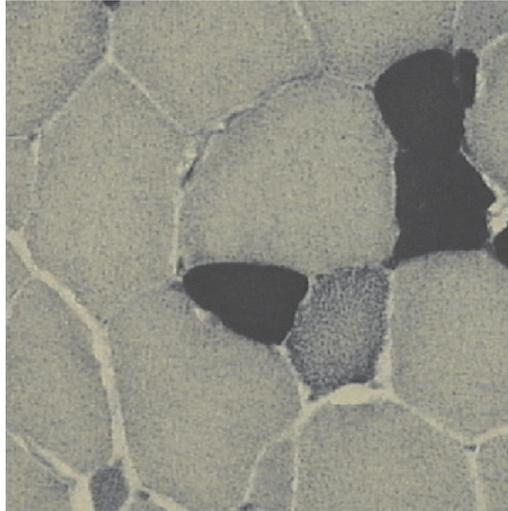


Photo 1. Cross-section through *longissimus lumborum* muscle of the Landrace pig no. 149. Magn.

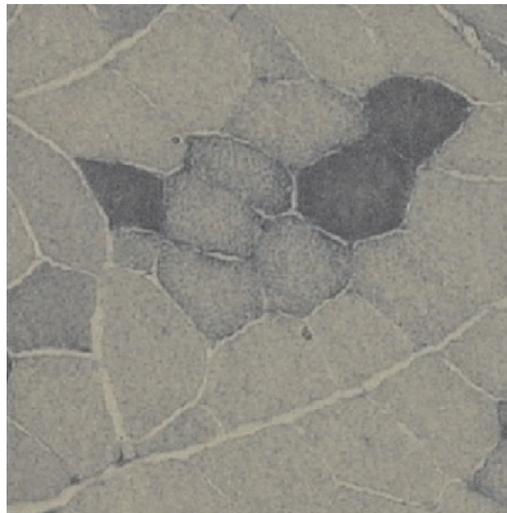


Photo 2. Cross-section through *longissimus lumborum* muscle of the Stamboek pig no. 10. Magn.

(STO – 43.12, FTO – 37.76, and FTG – 49.90 μm) and the highest number of fibres per unit area (230.50). Thus, the meat content of carcasses in S results from the increase of muscle fibres (hyperplasia), which was also noted in pigs of line PIC [Kłosowska *et al.* 1998] and Naima \times P-76 [Kłosowska *et al.* 2002]. The largest diameters of all fibre

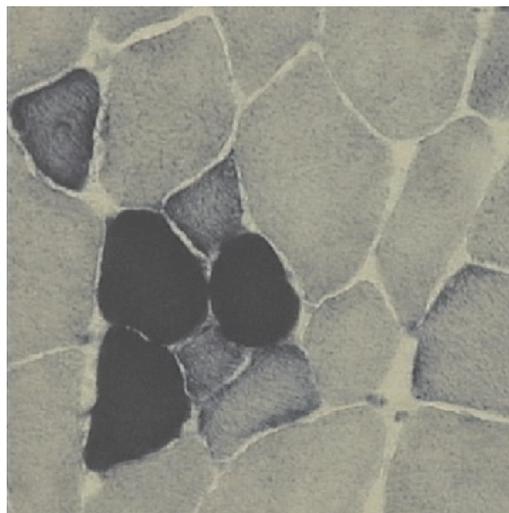


Photo 3. Cross-section through *longissimus lumborum* muscle of the Torhyb pig no. 63. Magn. 12.5×10.

types occurred in LL of the purebred PL pigs in which the diameter of STO fibres was 46.80, of FTO – 43.62 and of FTG – 61.08 μm . The number of fibres per 1.089 mm^2 was smallest in PL pigs (178.05).

Correlation coefficients between traits of LL microstructure and selected fattening, slaughter and meat quality traits are presented in Table 3. The relationship was shown between daily gain and the diameter of FTO fibres ($r=0.212$). The LL microstructure was also related to meat content of carcass. It is worth noting that the per cent of FTG fibres was negatively correlated with both loin eye area ($r=-0.332$) and meat content of ham ($r=-0.348$) and of carcass ($r=-0.277$). Based on the positive correlation coefficients between meatiness and per cent of STO fibres, it is concluded that the increase in meatiness was accompanied by the increased per cent of oxidative fibres. The correlation coefficients do not follow those found by Kłosowska [1973] and Nowak *et al.* [1994], who reported increasing per cent of glycolytic fibres with increasing meatiness in pigs.

REFERENCES

Table 3. Correlations coefficients between number of myofibrils (sarcomere rate, sarcomere and fibre size), length and irregularity ratio

Trait		Daily gain (g)	Mean back fat depth from P8 to P12 (mm)	Lean eye area (cm ²)	Microsarcomere off-tune (1%)	Microsarcomere off-tune (1%)	pH	Water holding capacity (1% basis value)
Share of fibres (%)	STD	0.056	-0.001	0.131*	0.101*	0.101	0.01*	-0.040
	PTD	-0.019	0.111	0.113	0.075	0.050	-0.105	0.007
	ETC	0.007	-0.036	-0.112**	-0.108**	-0.117**	0.069	0.031
Fibre diameter (µm)	STD	0.061	0.091	-0.051	-0.101	-0.171	-0.106	-0.001
	PTD	0.112*	0.109	0.091	-0.057	-0.117*	-0.190	-0.046
	ETC	0.150	0.197	0.050	-0.076	-0.101*	-0.105	0.01*
Number of fibres per 1000 mm ² area		-0.048	-0.171	-0.13*	-0.101	0.057	0.108**	-0.171

*P < 0.05, **P < 0.01

1. BLICHARSKI T., OSTROWSKI A., 1996 – Wstępne badania nad wartością rzeźną świń “STAMBOEK”. (Preliminary studies on slaughter value of STAMBOEK pigs). *Zeszyty Naukowe Przeglądu Hodowlanego* 26, 169-176.
2. BZOWSKA M., PTAK J., KARPOWICZ A., 2003 – Wyniki oceny trzody chlewnej w 2002 (The results of swine evaluation in 2002). In Polish. KCHZ Warszawa.
3. ČANDEK-POTOKAR M., LEFAUCHEUR L., ŽLENDER B., BONNEAU M., 1999 – Effect of slaughter weight and/or age on histological characteristics of pig *longissimus dorsi* muscle as related to meat quality. *Meat Science* 52, 195-203.
4. GRAU R., HAMM R., 1952 – Eine einfache Methode zur Bestimmung der Wasserbindung im Fleisch. *Fleischwirtschaft* 4, 295-296.
5. HENCKEL P., OKSBJERG N., ERIANDSEN E., BARTON-GADE P., BEJERHOLM C., 1997 – Histo- and biochemical characteristics of the Longissimus Dorsi muscle in pigs and their relationships to performance and meat quality. *Meat Science* 47, 3/4, 311-321.
6. KAPELAŃSKI W., BOCIAN M., KAPELAŃSKA J., HAMMERMEISTER A., GRAJEWSKA S., 1998 – Ocena jakości mięsa tuczników z udziałem rasy pietrain. [Meat quality of porkers with a share of Pietrain blood]. In Polish with English summary. *Prace i Materiały Zootechniczne, Zeszyt Specjalny* 8, 91-97.
7. KAPELAŃSKI W., HAMMERMEISTER A., 1999 – Wartość tuczna i rzeźna mieszańców trójrasowych produkowanych według programu TORHYB. (Fattening and slaughter values of three-breed hybrids produced according to TORHYB programme). Międzynarodowa Konferencja Naukowa “Aktualne problemy w produkcji trzody chlewnej” (International Scientific Meeting “Current Problems on pig production”), ART Olsztyn, May 6, 87.
8. KŁOSOWSKA D., 1973 – Czerwone i białe włókna w mięśniach różnych ras świń. (Red and white fibers in the muscles of pigs of different breeds). *Zeszyty Problemowe Postępów Nauk Rolniczych* 139, 199-205.
9. KŁOSOWSKA D., BORZUTA K., ZAWADZIŃSKA B., 1995 – Muscle microstructure of the pig crossbred Polish landrace with pietrain stress. International Scientific Meeting “Current Problems on pig production”. ART Olsztyn.
10. KŁOSOWSKA D., GRZEŚKOWIAK E., ELMINOWSKA-WENDA G., WALASIK K., BOGUCKA J., 2002 – Microstructural characteristics of M. longissimus lumborum of the pigs synthetic line (Naima x P-76) in relation with meatiness and some meat quality parameters. *Annals of Animal Science* 2, 305-309.
11. KŁOSOWSKA D., GRZEŚKOWIAK E., LUTHER R., ELMINOWSKA-WENDA G., 1998 – Microstructural characteristics of longissimus muscle in syntetic hybrid line (PIC) pigs and meat quality. *Polish Journal of Food and Nutrition Sciences* 7/48, 4, 167-172.
12. LARZUL C., LEFAUCHEUR L., ECOLAN P., GOGUE J., TALMANT A., SELIER P., LE ROY P., MONIN G., 1997 – Phenotypic and genetic parameters for longissimus muscle fiber characteristics in relation to growth, carcass, and meat quality traits in Large White pigs. *Journal of Animal Science* 75, 3126-3137.
13. MICHALSKA G., KAPELAŃSKI W., HAMMERMEISTER A., BUCEK T., 2000 – Zależności między umięśnieniem tuszy a jakością mięsa mieszańców z udziałem rasy pietrain. (Relationships between carcass lean content and quality of meat of crossbred pigs with the share of Pietrain breed). In Polish with English summary. *Zeszyty Naukowe Przeglądu Hodowlanego* 48, 241-247.
14. NOWAK B., KŁOSOWSKA D., BLICHARSKI T., OSTROWSKI A., KOMENDER P., 1994 – Correlations between carcass muscularity, meat quality and microstructure of the muscle tissue in pigs. II-nd International Conference “The influence of genetic and non genetic traits on carcass and meat quality”, Siedlce, 7-8 November, 1994, 165-168.

15. WEGNER J., FIEDLER I., KŁOSOWSKA D., KŁOSOWSKI B., ZIEGAN B., 1993 – Veränderungen der Muskelfasertypenverteilung im M. longissimus dorsi von Ebern während des Wachstums dargestellt mit verschiedenen histochemischen Methoden. *Anatomia, Histologia, Embriologia* 22, 355-359.
16. WALSTRA P., MERKUS G.S.M., 1996 – Procedure for assessment of the lean meat percentage as a consequence of the new EU reference dissection method in pigs carcass classification. Report ID-DLO 96.014.

Joanna Bogucka, Wojciech Kapelański

Cechy mikrostruktury mięśnia *longissimus lumborum* świń rasy polskiej białej zwisłouchej oraz mieszańców uzyskanych w programach Stamboek i Torhyb

Streszczenie

Materiał stanowiło 98 wieprzków należących do trzech grup: czysta rasa pbz, mieszańce holenderskiego programu Stamboek (S) oraz mieszańce polskiego programu Torhyb (T). Do badań mikrostrukturalnych pobrano próbki mięśnia *longissimus lumborum* i zamrożono w ciekłym azocie. Następnie sporządzono preparaty mikroskopowe i poddano je reakcji histochemicznej dla wyróżnienia typów włókien mięśniowych, różniących się aktywnością enzymatyczną. Określono procentowy udział poszczególnych typów włókien mięśniowych i dokonano pomiaru ich średnic z wykorzystaniem komputerowego systemu analizy obrazu mikroskopowego Q 500 MC firmy Leica. Procentowy udział poszczególnych typów włókien mięśniowych kształtował się we wszystkich grupach świń na podobnym poziomie. Udział włókien STO wahał się w granicach od 13,42% (świnie T) do 14,90% (świnie pbz). U mieszańców T zaobserwowano najwięcej włókien FTO (18,50%), a najmniej włókien FTG (68,08%) spośród wszystkich badanych grup świń. Najmniejszym udziałem włókien FTO (16,00%) oraz największym udziałem włókien FTG (70,50%) charakteryzowały się świnię S. W mięśniu świń S stwierdzono najmniejsze średnice wszystkich typów włókien mięśniowych (STO- 43,12, FTO- 37,76 i FTG- 49,90 μm) oraz najwięcej włókien na powierzchni 1,089 mm^2 (230,50). Nadto tuczniaki S charakteryzowały się najkorzystniejszym pH_1 (6,41) i WHC (19,78%). Lepsze cechy

