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 mm² (230.50). The most beneficial pH 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

The aim of the present study was to assess the microstructure of *longissimus lumborum* muscle in purebred Polish Landrace pigs and in crossbreds 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 crossbreds (S, n=39);
- Torhyb crossbreds (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:

\[
\text{female LW (maternal line)} \times \text{male LW (maternal line)} \rightarrow \text{female F}_1 \times \text{male LW (paternal line)} \rightarrow \text{fattening}
\]

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

\[
\text{female PLW} \times \text{male PL} \rightarrow \text{female F}_1 \times \text{male Pietrain} \rightarrow \text{fattening}
\]

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* pH₁ 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 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 crosses 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 crosses 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>
<thead>
<tr>
<th>Trait</th>
<th>Group</th>
<th>PL</th>
<th>Stambuk</th>
<th>Toszbka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loin eye area (cm²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>mean (SD)</td>
<td>14.90 (2.83)</td>
<td>13.30 (2.60)</td>
<td>13.42 (3.37)</td>
</tr>
<tr>
<td>FTO</td>
<td>mean (SD)</td>
<td>16.43 (4.32)</td>
<td>15.30 (4.73)</td>
<td>15.30 (4.92)</td>
</tr>
<tr>
<td>FTG</td>
<td>mean (SD)</td>
<td>70.02 (5.30)</td>
<td>70.30 (4.21)</td>
<td>68.68 (5.00)</td>
</tr>
<tr>
<td>Fibre diameter (µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STO</td>
<td>mean (SD)</td>
<td>46.80 (3.84)</td>
<td>42.12 (4.30)</td>
<td>43.74 (3.37)</td>
</tr>
<tr>
<td>FTO</td>
<td>mean (SD)</td>
<td>45.62 (3.03)</td>
<td>39.76 (4.90)</td>
<td>38.90 (4.30)</td>
</tr>
<tr>
<td>FTG</td>
<td>mean (SD)</td>
<td>61.08 (6.42)</td>
<td>49.90 (6.23)</td>
<td>52.30 (6.55)</td>
</tr>
<tr>
<td>Number of fibres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>per 1.089 mm² area</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>mean (SD)</td>
<td>178.05 (28.30)</td>
<td>250.30 (42.30)</td>
<td>187.20 (32.91)</td>
</tr>
</tbody>
</table>

**Within rows means bearing different superscripts differ significantly at:
small letters - P<0.05; capital - P<0.01.**
Microstructure of muscle in crossbred pigs

(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 × P-76 [Kłosowska et al. 2002]. The largest diameters of all fibre


Photo 2. Cross-section through *longissimus lumborum* muscle of the Stamboek pig no. 10. Magn.
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 mm² 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>
<thead>
<tr>
<th>Trait</th>
<th>Daily gain (g)</th>
<th>Mean backfat thickness (mm)</th>
<th>Lean eye area (mm²)</th>
<th>Percentage of fat (%)</th>
<th>Percentage of lean (%)</th>
<th>pH</th>
<th>Water holding capacity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of fat (%)</td>
<td>ST</td>
<td>D 056</td>
<td>D 001</td>
<td>D 333</td>
<td>D 1+3</td>
<td>D 01=</td>
<td>-DDID</td>
</tr>
<tr>
<td></td>
<td>TR</td>
<td>-D 019</td>
<td>D 111</td>
<td>D 112</td>
<td>D 075</td>
<td>D 050</td>
<td>-D 1+5</td>
</tr>
<tr>
<td></td>
<td>TGR</td>
<td>D 0-0 T</td>
<td>-D 016</td>
<td>-D 112</td>
<td>-D 1+3</td>
<td>-DDID</td>
<td>-DDID</td>
</tr>
<tr>
<td>Phbte</td>
<td>ST</td>
<td>D 061</td>
<td>D 001</td>
<td>-D 051</td>
<td>-D 1+1</td>
<td>-D 066</td>
<td>-DDID</td>
</tr>
<tr>
<td></td>
<td>TR</td>
<td>-D 113</td>
<td>D 189</td>
<td>D 091</td>
<td>-D 076</td>
<td>-D 217</td>
<td>-D 090</td>
</tr>
<tr>
<td></td>
<td>TGR</td>
<td>D 150</td>
<td>D 19T</td>
<td>D 090</td>
<td>-D 101</td>
<td>-D 066</td>
<td>-DDID</td>
</tr>
<tr>
<td>Number of MBs per 100 g meat</td>
<td>-DDID</td>
<td>-D 117</td>
<td>-D 12+</td>
<td>-D 101</td>
<td>DDID</td>
<td>D 117</td>
<td>-DDID</td>
</tr>
</tbody>
</table>

*P < 0.05, **P < 0.01
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.
Streszczenie

Materiał stanowiło 98 wieprzków należących do trzech grup: czysta rasa pbz, mieszance holenderskiego programu Stamboek (S) oraz mieszance 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 mieszance 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 świnie S. W mięśniu świni S stwierdzono najmniejsze średnice wszystkich typów włókien mięśniowych (STO- 43,12, FTO- 37,76 i FTG- 49,90 µm) oraz największej włókien na powierzchni 1,089 mm² (230,50). Nadto tuczniki S charakteryzowały się najkorzystniejszym pHₙₐ₅ (6,41) i WHC (19,78%). Lepsze cechy

Joanna Bogucka, Wojciech Kapelański

Microstructure of muscle in crossbred pigs

