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Structure Traits of *Longissimus lumborum* Muscle in Wild Boar/domestic Pig Hybrids

Gabriela ELMINOWSKA-WENDA

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The structure of *musculus longissimus lumborum* (*m.l.l.*) was evaluated with respect to proportion of three muscle fiber types and their diameters, in gilts and barrows of wild boar/domestic pig hybrids. The experiment was carried out on 29 hybrids (21 barrows and 8 gilts) which originated from crossing Duroc sows with wild boar (*Sus scrofa ferus*). The diameter of the "red" fibres in barrows was 48.42 μm, significantly greater than in gilts – 43.71 μm. The diameters of the remaining two types of fibres in barrows and gilts were similar and amounted to: "intermediate" fibres – 39.08 and 40.79 μm, "white" fibres – 51.42 and 51.03, respectively. In respect to sex no statistical differences in proportion of any types of fibers were found, which in barrows came to: "red" – 12.93 %, "intermediate" – 30.17 % and "white" – 57.32 %, and in gilts to: 12.50, 27.04 and 60.45 %, respectively. In conclusion, in *m.l.l.* of wild boar/domestic pig hybrids, smaller diameters of all muscle fibers types were identified as well as a higher proportion of intermediate fibers in comparison to *m.l.l.* of various pig breeds. An increased proportion of the intermediate fibers probably results from the interaction between factors such as age (8- months), physical activity (open-air for running) and the influence of wild boar genes.

Key words: Muscle, structure, fibers, hybrid, wild pig.

Gabriela ELMINOWSKA-WENDA, Department of Animal Biotechnology, University of Technology and Agriculture, Mazowiecka 28, 85-084 Bydgoszcz, Poland.
E-mail: histol@atr.bydgoszcz.pl

Crossing species of domestic animals with their wild equivalent makes for a convenient model that allows defining the changes resulting from human activity. These changes usually involve biology, behavior, genetics and physiology, and knowledge of these changes may have a practical application.

Crossing the domestic pig (*Sus scrofa domesticus* L.) with the wild boar (*Sus scrofa ferus* L.) makes it possible to obtain high-quality raw meat with attractive culinary and dietary properties. Similar attempts on improvement of the quality of raw meat were successfully applied in crossing the European bison with domestic cattle (KŁOSOWSKI *et al*. 1988) and the Greylag goose with the goose of currently reared breeds and varieties (MAZANOWSKI *et al*. 2005).

WALKIEWICZ *et al.* (1998) showed that the slaughter value of the wild boar/Duroc sow hybrids (including carcass weight, loin weight and slaughter value) was similar to the Polish Landrace fatteners. Favorable parameters of the tissue composition as well as the physical and chemical properties of the meat and fat in wild boar and wild boar/domestic pig hybrids was reported inter alia by WIELBO *et al*. (2002) and GRONEK *et al*. (1994).

A direct relation between meat content, carcass quality and muscle microstructure features has been emphasized in research conducted on various animal species (KŁOSOWSKA *et al*. 1994; NOWAK *et al*. 1994; HENCKEL *et al*. 1997; ČANDEK-POTOKAR *et al*. 1998; KARLSSON *et al*. 1999; BROCKS *et al*. 2000; KŁOSOWSKA & FIEDLER 2003; GONDRET *et al*. 2006). The crucial parameter differentiating muscles with respect to their morphology is the thickness of the muscle fibers, expressed either as their diameter or as cross – section area. These values are influenced by breed, sex, age, muscle type as well as the feeding system, body weight and the physical activity of the animals (see review KARLSSON *et al*. 1999).

The aim of this research was the histochemical evaluation of the structure of *musculus longissimus lumborum* (*m.l.l.*) with respect to the percentage proportion of three muscle fiber types and their diameters, in gilts and barrows of wild boar/domestic pig Duroc hybrids.

Material and Methods

The experiment was carried out on 29 hybrids (21 barrows and 8 sows) of Duroc sows with wild boar (*Sus scrofa ferus* L.). All the animals were fed (*ad libitum* with composed fix) from weaning up to the age of approx. 8 months.

The samples of *longissimus lumborum* muscle were taken approx. 45 min after slaughter, and frozen in liquid nitrogen. Transverse serial sections (10 μm thick) were cut in a cryostat at – 20^{o} C, and put on slides on which a combined histochemical reaction was performed for myofibrillar ATPase and NADH-tetrazolium reductase (oxidative enzyme), according to the ZIEGAN method (ZIEGAN 1979), in order to distinguish between the three main types of muscle fibers: "red" fibers (slow-twitch oxidative, PETER *et al*. 1972), "intermediate" fibers (fast-twitch oxidative) and "white" fibers (fast-twitch glycolytic). The microscopic images were subsequently uploaded to a computer and analyzed with the use of digital picture analysis (Leica Q500MC). The measurements of the shortest diameters (according to BROOKE 1970) were taken on ten pictures from each sample/individual. The general number of fibers measured varied across individuals and was between 307 to 551. The percentage proportion of three muscle fiber types in the bundle was expressed as mean value calculated from ten muscle bundles. The results were analyzed statistically using Student's *t*-test (PC STAT, 1990).

Results and Discussion

The microscopic image of the cross – section structure of the *longissimus lumborum* muscle in wild boar/domestic pig hybrids is presented in the Figs 1,2. The presence of three types of muscle fibers as well as their order in the bundle is typical for the microstructure of this muscle in currently produced commercial pig breeds. The red fibers are situated in the middle part of the bundle, surrounded by the intermediate fibers, and on the periphery of the cross – section numerous white fibers are visible.

The diameters of the red fibers in the barrows were significantly larger ($P<0.01$) than in gilts (Table 1). The diameters of the two remaining types of muscle fibers in the two analyzed groups were similar.

As follows from prior research of other authors (see review KARLSSON *et al.* 1999), among many factors influencing the diameter of fibers, the impact of the animal gender is the least proved.

The diameters of fibers obtained in this study in the muscle of wild boar/domestic pig hybrids were smaller than in various pig breeds of similar body weight. It needs to be emphasized that the wild boar/domestic pig hybrids had a slaughter weight that was approximately two months later than the commercial fatteners. It may be expected that the differences in the fiber diameters would have been even larger if they would have been measured in hybrids examined about 2 months earlier. Besides, the red fiber diameters in the hybrids examined differed least in size from the average diameters of the red fibers in pigs.

Similarly as in other species, the fiber diameters in pigs increase with growth. This fact is confirmed by earlier research, inter alia by KŁOSOWSKA *et al.* (1987/1988), KŁOSOWSKA *et al.* (1990). KŁOSOWSKA *et al.* (1987/1988) investigated fiber diameter growth in pigs between the second and fifth months of life. Pigs of this age demonstrated growth in all fiber types, but white fiber type growth was the highest with diameter increases of 100%.

The diameters of the muscle fibers in pigs increase also after the fifth month of life, shown in this study and in KAPELAŃSKI *et al.* (2006) who examined sows slaughtered after the first farrowing at the age of approx. 11 months. These authors examined the *m. longissimus lumborum* and demonstrated greater diameters of all fiber types in comparison to the diameters of the five months or younger slaughter fattener gilts. However, the largest difference related to the red fibers was the diameter, greater by about 10 μm in older sows.

Similar data was published by ČANDEK-POTOKAR *et al.* (1999), who investigated the impact of age (approx. 6 and 7.5 month) and body weight (approx. 100 and 130 kg, respectively) on cross – sectional area of the fibers in *musculus longissimus lumborum* of the pig crossbreeds (Duroc x Landrace x Large White). They described a significant increase of the red and white fiber thickness in 1.5 month older fatteners, mentioning that the red fiber growth was highly significant.

The data presented here and the other authors indicate that in pigs and wild boar/domestic pig hybrids above 6 months of age, the highest growth rate is demonstrated by red fibers, in contrast to the growth of white fibers in which the highest growth rate occurs from birth to approx. 5-6 month of life (SOLOMON *et al.* 1981; KŁOSOWSKA *et al.* 1987/1988; WEGNER and ENDER 1990; FIEDLER *et al*. 1991.

The diameters of the red fibers in *musculus longissimus lumborum* in the wild boar/domestic pig hybrids of both sexes were much greater than the diameters of the intermediate fibers (Table 1). The same dependence was observed in *musculus long-*

Table 1

Fiber type composition within the bundle (%) and fiber diameters (μm) of *m. longissimus lumborum* in wild boar/domestic pig hybrids. Mean values and standard deviation (in parenthesis)

Groups	Carcass weight[1] (kg)	Fiber type within the bundle (%)			Fiber diameters (μm)		
		Red	Intermediate	White	Red	Intermediate	White
Barrows n = 21	68.31 (17.05)	12.93 (2.10)	30.17 (5.17)	57.32 (5.55)	48.42* (4.01)	39.08 (3.22)	51.42 (4.06)
Gilts n = 8	71.86 (13.95)	12.50 (4.93)	27.04 (4.94)	60.45 (5.52)	43.71* (2.90)	40.79 (2.08)	51.03 (2.08)
All n = 29	69.29 (16.33	12.82 (3.15)	29.38 (5.37)	58.2 (5.72)	47.12 (4.29)	39.61 (3.07)	51.44 (4.06)

[1] warm carcass weight

* values significantly different with sex (P<0.01)

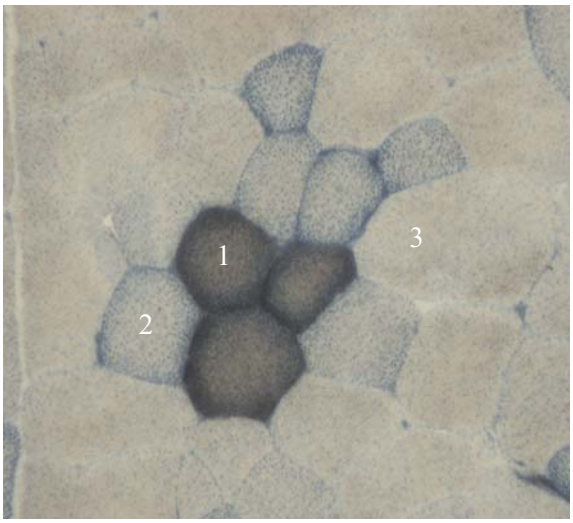

Fig. 1. Fiber type composition within the bundle of *m. longisimus lumborum* in wild boar/domestic pig hybrids, ×200. 1 – red fiber; 2 – intermediate fiber; 3 – white fiber.

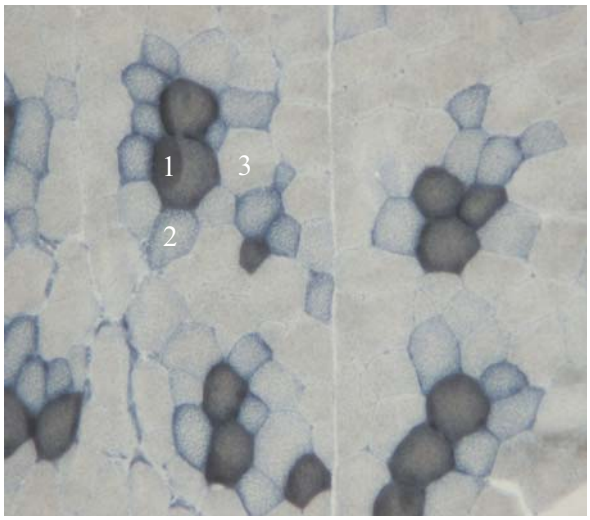

Fig. 2. Structure of bundles in *m. longissimus lumborum* wild boar / domestic pig hybrids, ×100. 1 – red fiber; 2 – intermediate fiber; 3 – white fiber.

issimus lumborum of the sows slaughtered at the age of 11 months (KAPELAŃSKI *et al.* 2006). Other researchers (WICKE *et al.* 1998; KŁOSOWSKA *et al.* 1998) examined 5-6 month old fatteners in which the difference in thickness of these two fibers types was reversed and smaller (3-5 μm).

The available literature concerning the diameter of the muscle fibers in the wild boar is not conguent. In one of the few publications concerning wild boar muscle microstructure, WIELBO and LECHOWSKI (2002) compared the fiber diameters in *musculus longissimus lumborum* in wild boar and Polish Large White pigs. They showed that the diameters of the fibers in *musculus longissimus lumborum* in wild boar were smaller by approx. 15 μm. Unfortunately they did not include detailed data on each fiber type. However, divergent data was published by other authors (RAHELIC & PUAC 1980-81; SZENTKUTI *et al.* 1981; BADER 1983; KARLSTROM *et al.* 1995; see review KARLSSON *et al.* 1999), who observed the same or even larger diameters of the red fibers and intermediate fibers in *m. longissimus lumborum* in wild boar than in the domestic pig.

In this study, significant differences in percentage proportion of all types of fibers in *musculus longissimus lumborum* in both sexes were not observed (Table 1). However, the large, amounting to almost 30%, proportion of intermediate fibers in this muscle draws attention. It is hard to unambiguously determine the reason of such a large proportion of intermediate fibers in *m. longissimus lumborum* in wild boar/domestic pig hybrids. Perhaps the larger proportion of the intermediate fibers in the hybrids results from their age (about

8 months) as well as from the conditions in which animals were kept (open-air for running), and/or the genetic influence of the wild boar.

KAPELAŃSKI *et al.* (2006) found a significantly larger proportion of intermediate fibers in *musculus longissimus lumborum* in first farrowing gilts at the age of 11 months, in comparison to the fattener gilts at the age of approx. 6 months. In investigations concerning the impact of the breed on percentage proportion of the fibers in the *musculus longissimus lumborum*, the largest proportion of intermediate fibers was found in the pig breed Zlotnicka spotted by KŁOSOWSKA *et al.* (2001) (23.77%) from a conservative breeding system in comparison to such breeds as Pietrain (17.70%) or Polish Landrace (14.13%). The above data as well as the present results suggest that this feature is characteristic for free-living animals (wild boar) and/or those subjected to limited selection pressure (Zlotnicka spotted, conservative herd).

The sum of percentage proportions of the red and intermediate fibers – the fibers characterized by a greater oxidative capacity than the white fibers – equals on average 42% (Table 1). This value is higher than the values published by other authors in commercial pig breeds with the highest meat content, e.g. PIC or Pietrain (KŁOSOWSKA *et al.* 1998; KŁOSOWSKA *et al.* 2001). Similarly KAPELAŃSKI *et al.* (2006) noted in 6 month old Polish Landrace pigs in the same muscle 28% of the red and intermediate fibers altogether, thus about 13% less than in the wild boar/domestic pig hybrids examined.

Such a large proportion of oxidative fibers is characteristic for the muscles of wild animals. The same was shown in the comparative research on European bison, the bison/bovine hybrids F1 (hybrids of European bison with ncb and Charolaise cattle breeds) as well as on pure Black-and-white, conducted by KŁOSOWSKI *et al.* (1988). In a homological muscle to the one analyzed in this study, the authors found 78% of the oxidative fibers (red and intermediate) in European bison and as much as 20% less in the Black-and-white cattle breed. Also, significantly more oxidative fibers were found in other bison muscles as compared to the same muscles of the Black-and-white cattle breed. WIELBO and LECHOWSKI (2002) noted more red fibers in the *musculus longissimus lumborum* of the wild boar than in the same muscle of Polish Landrace (no numerical data published). Similarly other authors, i.e. REDE *et al.* (1986) and ESSEN-GUSTAVSSON and LINDHOLM (1984) see review: KARLSSON *et al.* (1999) found a larger proportion of red fibers in the *musculus longissimus lumborum* in the wild boar in comparison to this quantity in the domestic pig (inter alia Swedish Landrace pigs), whereas they didn't note a larger proportion of intermediate fibers.

The phenomenon of fiber transformation may be stimulated by the physical activity of the animals (CLAUSEN 1969; WATERS *et al.* 2004). The research of the latter indicated that physical exertion induces angiogenesis around the fibers of the IIB/IIX type (white), and this process precedes the transformation of those fibers into the IIA fiber type (intermediate).

In the present experiment the wild boar/domestic pig hybrids had access to the run for the whole period of fattening, which means that the conditions were completely different from the standard conditions for keeping fatteners. Access to the run means not only additional movement that induces better muscle microcirculation, but also indirectly it is a factor influencing the transformation of the white fibers into intermediate fibers (ESSEN- GUSTAVSSON *et al*. 1993; WATERS *et al.* 2004).

Additionally, the number of fiber types may be influenced by the fattening season. KŁOSOWSKA *et al.* (1976) in research on the impact of the season on the quantity of each muscle fiber type in *musculus longissimus lumborum* in the pig found a significantly higher proportion of the intermediate fibers during the fall fattening season in comparison to spring. However, this difference was not found for the fibers with the highest oxygen metabolism – the red fibers. In the current study, the fattening of the wild boar/domestic pig hybrids was performed in the autumn/winter season.

The current study suggests the adaptive potential of the muscle fibers, and in effect of all the skeletal muscles, to the particular environmental conditions. Moreover, it confirms the differentiation in the heterogenic structure of the homological muscles in animals from closely related species.

In conclusion in *m.l.l.* of the wild boar/domestic pig hybrids examined, smaller diameters of all muscle fiber types were identified as well as a higher proportion of the intermediate fibers in comparison to *m.l.l.* of various pig breeds. The increased proportion of the intermediate fibers results probably from the interaction between such factors as age of the animals (8- months), physical activity (open-air for running) and the influence of the wild boar genes.

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