THE INFLUENCE OF GROWTH INTENSITY DURING DIFFERENT AGE PERIODS ON MUSCLE FIBER CHARACTERISTICS IN PIGS

Brzobohatý L., Stupka R., Čítek J., Šprysl M., Okrouhlá M., Vehovský K.
brzobohaty@af.czu.cz

Czech University of Life Sciences Prague, Czech Republic

Abstract

The aim of the study was to find a period with a significant influence on the ratio of individual muscle fiber types, based on correlation analysis and intensity of pig growth and age. The test was carried out with the use of 72 animals (balanced sex – gilts/barrows) of the Danbred genotype and weight extent of 25-115kg. Pigs were fed ad-libitum (according to the body weight) by complete feed mixtures A1, A2, A3. The growth intensity in relation to the muscle fiber characteristics was evaluated, based on the average daily gain (ADG) observed during four different age periods, determined as follows: period A 70-84 days, period B 85-105 days, period C 106-134 days and period D 135-154 days. Following the slaughter the muscle fiber parameters (diameter and perimeter) and typology (the percentage of individual types of muscle fibers – I, IIA and IIB) were determined based on the analysis of samples obtained from the *m. longissimus thoracis et lumborum* (MLLT). The period A and C showed significant positive correlations (P <0.001), where with increasing ADG the proportional share of type I muscle fibers increased, while the share of muscle fiber types IIA and IIB decreased. The period D demonstrated a positive correlation (P <0.001) between the change of ADG and proportional share of the slow glycolytic fibers IIB.

Key Words: Pig, growth intensity, muscle fiber, types

The main product of modern genotypes pigs is meat. The highest attention today is placed on its quality and quantity. The most significant intensification factors influencing production potential are growth intensity and slaughter value. Both of these traits pose major influence on the effectiveness of breeding herds.

Like any other commercial characteristic, the growth intensity is the result of both internal (breed, sex, age) and environmental factors working together (nutrition, feeding technique, technology), as shown by Serrano et al. (2009) and Stupka et al. (2009). The highest growth intensity was found in young animals. The body composition of growing pigs changes based on their body weight and the length of the fattening period. Absolute daily gain increases with the age of pigs, while the relative gain decreases (Stupka et al., 2009).

Out of the external conditions, the nutrition of pigs was found to be of the greatest importance (Bee et al., 2007). The level of nutrition and feeding strategy affects the amount of the body fat deposits, fat enzyme activity and thus the fatty acid profile is influenced as well (Šprysl et al., 2011; Skiba et al., 2012). Many authors state that there are certain interactions between the fatty acid profile and muscle fiber types (Bee et al., 2007). This fact suggests that the change in muscle fiber types could affect the final quality of pork meat (especially as expressed by its tenderness). The analysis of muscle structure is usually carried out during one growth phase, which is usually the one during which the pigs reach the standard slaughter weight (Skiba et al., 2012). As stated by this author, different levels of nutrient intake (energy, protein) affect the intramuscular fat content and the fatty acids proportion, as well as the proportion of individual muscle fiber types, while the area of the muscle fibers composing the MLLT remains unaffected.

The number of muscle myofibrils is determined during the prenatal period, therefore the postnatal increase in muscle mass depends mainly on the hypertrophy of myofibrils (Bee et al., 2007; Stupka et al., 2011). The postnatal period is also characterized by metabolic differentiation of the muscle fibers. Following the birth most of the myofibrils are of the oxidative type, but with increasing age the muscle metabolism becomes mainly glycolytic. (Lefaucheur, 2001). In this regard, Harrison et al. (1996) reported that a strong feed restriction after weaning affects hypertrophy of myofibrils and also changes the muscle fiber type proportions.

The main hypothesis of this study predicts that different intensity of growth in different periods of fattening affects the proportion of muscle fiber types in pigs. These differences will be observed and analyzed following the slaughter.

The aim of the study was to find a period with a significant influence on the ratio of individual muscle fiber types, based on correlation analysis and intensity of pig growth and age.

Material and Methods

During the course of the test 72 pigs (36 barrows and 36 gilts) of the Danbred genotype were used. The average live weight at the beginning of the test was 20 kg, rising to 115 kg at the end of the test. Animals were kept in pairs of the same sex. The animals were fed with three types of complete feed mixture (CFM), according to their current body weight (A1:20-35, A2:36-65, A3:66-115kg). The nutrient composition of CFM is shown in Table 1.

The growth intensity in relation to the muscle fiber characteristics was assessed according to the average daily weight gain (ADG) during four individual age-periods. As shown in Table 2, the period A = 70-84 days, period B = 85-105 days, period C = 106-134 days and the period D = 135-154 days. Following the slaughter 36 muscle samples from *m. longissimus thoracis et lumborum* (MLLT) (in 18 barrows and 18 gilts) were obtained. The samples (2x0.5cm size) were frozen with the use of liquid N_2 as well as 2-methylbutane. In order to obtain histological slides the tissue samples were cut with the use of Leica microtome, with the optimal selected thickness of 12 microns. Following the fixation (in alkaline preincubation) and staining, the slides were placed under a Nikon C-600 microscope and photographed (Brooke, Keiser, 1970). After the preparation of the histological slides the muscle fiber parameters (diameter, perimeter) and typology (the proportional share of muscle fiber types I, IIA and IIB) were determined.

For the purposes of data evaluation the software for image analysis (NIS - Elements AR version 3.2) and SAS statistical software version 9.2, using the GLM procedure with fixed effects and CORR, were used.

$\boldsymbol{Y_{ijk} = \mu + s_i + \gamma_j + \beta_k}$, where

Y_{ijk} = value character,

μ = the average of the group,

s_i = effect of sex (i = 1, 2),

γ_j = regression of the weight of carcass halves in cold,

$ß_k$ = regression of the weight gain in evaluation period (A, B, C, D).

Table 1. Nutrient composition of the complete feed mixtures (CFM)

CFM / live body weight (kg)	**A1**	**A2**	**A3**
	22 – 35	36 – 65	66 – 115
MEp (MJ)	13	12.9	12.8
NL (g)	187.94	170	146.93
LYZ (g)	12	10.61	8.7
MET (g)	3.32	3.17	2.99

Table 2. The intensity of growth in relation to age, body weight and average daily gains

Period	**Age (day)**		**Body weight (kg)**		**Average daily weight gain (g)**
	from	to	from	To	
A	70	84	27	48	1279
B	85	105	49	72	1295
C	106	134	73	104	1296
D	135	154	105	122	1424

Results and Discussion

The significance of individual influences used in the statistical model is shown in the Table 3. It is evident that the effects applied in the statistical model were not statistically significant (α <0.01), with the exception of the ADG during the period D. Many studies consider sex, age, muscle type, hormonal control and breed to be significant variables affecting the proportional share of individual muscle fiber types in the muscle (Karlsson et al., 1999; Rehfeldt et al., 2004).

The results of our study are documented in the Table 4. As it is evident from the values of correlation coefficients, there was no relationship found between the ADG during individual age periods and muscle fiber diameter. A similar finding was demonstrated for the muscle fiber perimeter values, where the correlation coefficients were not statistically significant. Our results are in accordance with Oksbjerg et al. (1994), who state that modern pig genotypes with the weight range of 25-90kg display almost constant rate of increase in the muscle fiber area. However Karlsson et al. (1999) observed a different trend, where the area of a muscle cross section increased steadily during the growth period in all of the types of muscle fibers. These authors showed that the muscle fiber diameter (MLLT), as measured from birth to 25 days of age, increased by 100%, while on the other hand the muscle fiber diameter measured between 100-125 days of age increased only by 10%. The intensity of muscle fiber growth becomes very slow after reaching 150 days of age. The reason for our results being so different from these is the fact that the age period evaluated in our study starts when the pigs reach the average live weight of 20kg, which is after the intensive increase of muscle fiber area.

With regards to the individual periods, the period A showed significant correlations (P<0.001) between the ADG and muscle fiber types. With the increasing ADG the proportional share of slow oxidative muscle fibers of the type I increases as well, while the share of fast oxidative-glycolytic (type IIA) and fast glycolytic (type IIB) muscle fibers decreases.

The period B showed significant differences in correlations (P <0.001), where with the increasing ADG the proportional share of muscle fibers type IIA decreases and the share of muscle fibers type IIB increases.

The period C also showed significant correlations (P <0.001). With the increasing ADG the proportional share of muscle fibers type I increases, while the share of muscle fiber types IIA and IIB decreases. The observed change in proportional shares of muscle fiber types in relation to the ADG characteristic for the given period is in accordance with findings demonstrated in the period A. The last period, period D, displayed a significant positive correlation (P <0.001) between the change of ADG and proportional share of the muscle fibers type IIB.

The results of this study are consistent with those published by Oksbjerg et al. (1994), who state that the research into the muscle fibers metabolism suggests that oxidative capacity of muscle fibers is maintained (or decreases), while the glycolytic capacity increases with age. The conclusions of Karlsson et al. (1999) are also in accordance with our results, reporting that during the growth period there is an apparent decrease in the proportional share of oxidative fibers, while the share of glycolytic muscle fibers in MLLT increases.

The selection aimed at high number of muscle fibers and low frequency of large glycolytic fibers therefore leads toward improving the composition and meat quality, as documented by Fiedler et al. (2004).

Table 3. The significance of effects used in the statistical model

Effect	α
Sex	0.196
WCHC*	0.148
Weight gain A	0.094
Weight gain B	0.730
Weight gain C	0.706
Weight gain D	0.004

*Weight of carcass halves in cold

Table 4. The correlations between selected parameters

	WGPA	WGPB	WGPC	WGPD
Diameter	0,000	0,030	-0,005	-0,022
Perimetr	0,000	0,028	-0,002	-0,004
PTIMF	0.199***	-0,008	0,164***	-0,003
PTIIAMF	-0,207***	-0,314***	-0,156***	0,006
PTIIBMF	-0,207***	0,275***	-0,140***	0,102***

WGPA – weight gain period A
WGPB – weight gain period B
WGPC – weight gain period C
WGPD – weight gain period D
PTIMF – percentage of type I muscle fibers (of all fibers)
PTIIAMF – percentage of type IIA muscle fibers (of all fibers)
PTIIBMF – percentage of type IIB muscle fibers (of all fibers)
Without mark – no statistical significance
*** <0.001

Conclusion

Based on the obtained results it can be stated that the different growth intensity in individual pig-fattening periods affects the proportion of the muscle fiber types. The hypothesis of this study was therefore confirmed.

The calculated correlation coefficients indicate the absence of interactions between the growth rate, muscle fibers diameter and perimeter in individual growth periods. This finding is explained by the timing of our study, beginning with pigs weighing 25 kg, seeing as the intensive increase of muscle area occurs between the moment of birth and reaching the live weight of 25kg.

Period A and C showed significant correlations ($P<0.001$), where with the increasing ADG the proportional share of muscle fibers type I increased as well, while the share of muscle fibers type IIA and IIB decreased. The period D then displayed a significant positive correlation ($P<0.001$) between the change in ADG values and proportional share of slow glycolytic muscle fibers type IIB.

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This study was supported by an S grant from the Ministry of Education, Youth and Sports of the Czech Republic, project no. MSM 604607901 and internal grant SV12-52-21320.