THE EFFECTS OF GROWTH INTENSITY AND CARCASS PART ON THE QUANTITATIVE AND QUALITATIVE PARAMETERS OF MUSCLE FIBERS IN PIGS

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Abstract

The aim of the study was to assess the effects of growth intensity and carcass part on the quantitative and qualitative parameters of muscle fibers. The monitoring was carried out on 72 pigs of balanced sex of the (HxPN) x (LWDxL) genotype. The selected fattening indicators were monitored during the test. Following the slaughter, individual samples of muscle tissue were removed. The samples were obtained from the MLLT (*m. longissimus lumborum et thoracis*) and MS (m. semimembranosus) of all the pigs. Then, with the use of laboratory equipment, the muscle fibers parameters (numbers and areas) were determined. These were then divided according to their values into three separate groups (intervals) - the group with the lowest, middle and highest parameter values of muscle fibers.

It has been demonstrated that for the carcass parts of ham and loin, in the terms of muscle fibers characteristic and monitored growth intensity, the animals with lowest values of muscle fiber qualitative parameters (area) showed the lowest average daily gain and the lowest daily feed consumption. In terms of the feed conversion no general trend was demonstrated. Concerning the number of muscle fibers there was no significant trend found in relation to the monitored fattening performance indicators.

Key Words: Pig, growth, carcass part, muscle fibers

Muscle tissue is a contractile tissue of animals, which has the ability to perform movement. Muscle tissue originates mostly from the middle embryonic leaf, i.e. mesoderm, but possibly also from the mesenchyme. The basic structural unit of muscle tissue is a cell or sets of cells organized into higher structural levels. The thickness of muscle fibers is significantly influenced by sex, growth rate and age, as well as the breeding level (POUR, HOVORKA, 1977, 1980). The growth intensity of individual tissues changes considerably with relation to the age and achieved body weight. Muscle fibers grow linearly with increasing weight (and therefore with increasing age) of the animal. Regarding the number of muscle fibers, most authors consider this to be constant. However there are sporadic opinions stating that the number of muscle fibers does change, especially due to exposure to hunger or luxury food (ČUBOŇ et al., 2004). KULISEK et al. (2003), BEE et al. (2007) and STUPKA et al. (2011) state that during the postnatal period of muscle growth the number of muscle fibers does not increase (it can decrease due to degeneration and other damage to the tissue), while the area of muscle fibers can (and does) change. That is why the postnatal muscle growth can occur on the basis of three fundamental principles. There is muscle growth in length (which ends with the growth of musculoskeletal apparatus), steady increase of the muscle fibers thickness (diameter) and increase of the interstitial connective tissue area. POUR, HOVORKA (1977) state that the muscle fibers perimeter growth in pigs is evidential only up to 90-100 kg of weight and does not continue further.

The aim of the study was to assess the effects of growth intensity and carcass part on the quantitative and qualitative parameters of the muscle fibers.

Hypothesis: The various achieved levels of the fattening performance parameters affect the muscle fibers number and area.

Material and Methods

The monitoring was conducted at the Experimental Testing Station in Ploskov. For the purposes of the test there was a total amount of 144 animals of balanced sex used. The test included animals of an average age of 65-70 days and average live weight of 25 kg. All the pigs were of the (HxPN) x (LW_DxL) genotype. The animal housing was realized according to the current methodology for testing of purebred and hybrid pigs.

The nutrition of animals was carried out in accordance with the Nutrient requirements and tables of nutritive value of feeds for pigs (SIMECEK et al., 2000). The pigs were fed ad-libitum in three phases with continuous transition. The complete feed mixtures (CFMs) were composed of wheat, barley, extracted soybean meal (SEM) and feed supplement. Every CFM was mixed for each pen separately.

Before the beginning of the test the individual components of feed mixtures were analyzed and assessed based on their nutrition content. Following the analysis the CFMs were optimized according to the obtained values and the age and weight of the animals. Feed consumption was measured for a pair of pigs (one pen) and

subsequently recalculated in order to obtain the information for each individual animal.

During the course of the test the following fattening performance parameters were monitored in regular weekly intervals:
average daily gain (ADG in g)
feed conversion (FCR in kg)
daily feed intake (DFI in kg).

Following the end of the fattening period these parameters were used in order to calculate the average values for the whole experiment.

After the slaughter 72 samples of muscle tissue (from MLLT and MS) were collected. All the samples (of 2x0.5cm size) were frozen with the use of liquid nitrogen and 2-methylbutane. The histological slides were obtained by cutting the tissue from the loins with the use of Leica microtome, with the selected optimum thickness of 12µm. Subsequently the slides were dyed and fixated in alkaline preincubation (BROOKE, Keiser, 1970). Following the preparation of histological slides the muscle fiber photographs were taken with the use of Nikon C-600 microscope. Subsequently, the number and area of muscle fibers were determined in a laboratory.The selected muscle fiber indicators for each carcass part were monitored and divided according to their values into three groups (intervals). The group with the lowest, middle and highest value parameters of the muscle fibers were marked by the numbers 1, 2 and 3, respectively.

The data evaluation was performed with the use of image analysis software NIS - Elements AR, version 3.2 and with the use of the SAS program, version 2.9. The GLM procedure was used with fixed effects and CORR. The equation used for obtaining our values was as follows:

$\mathbf{Y_{ijk} = \mu + s_i + V_j + ß_k + e_{ijk}}$, where

Y_{ijk} = value character
μ = the average of the group,
s_i = effect of sex (also = 1, 2),
V_j = effect of muscle fibers frequency and area (also = 1, 2, 3),
$ß_k$ = regression of weight of carcass halves in cold,
e_{ijk} = residual error.

Table 1. The CFM nutrient contents

Item	*CFM component*				
	Wheat	Barley	SEM	Premix 1	Premix 2
Dry matter (g/kg of CFM)	880	880	928		
N-substances (g/kg of CFM)	125	111	448		
MEp (MJ/)	13,6	12,4	13,3		
Fibre (g/kg of CFM)	24,4	49,1	50,2		
Fat (g/kg of CFM)	18,9	19,8	17,2		
Lysine (g/kg of CFM)	3,4	3,8	28,1	84,0	63,0
Threonine (g/kg of CFM)	3,6	3,7	17,8	40,0	24,0
Methionine (g/kg of CFM)	2,0	1,7	6,5	22,6	8,0
Ca (g/kg of CFM)	0,6	0,6	2,4	140,0	119,5
P (g/kg of CFM)	0,8	1,0	1,9	60,5	43,5

Concerning the groups divided according to muscle fibers number (Table 2) it was found that the group with the smallest number of muscle fibers (46.39) reached a significantly higher growth intensity (ADG), as compared with the other groups, and also reached the highest DFI. For the FCR parameter there were no significant differences between the groups found. Regarding the muscle fiber areas, the group with the largest average muscle fibers area (9,454 µm²) also showed the lowest ADG, low DFI and FCR (as shown in Table 2). In terms of the muscle fibers area in the ham it is obvious that animals with the highest values are characterized by low growth rate and DFI, which corresponds with the findings published by POUR, HOVORKA (1977).

Regarding the other monitored carcass part, loin, pigs in groups divided according to muscle fibers number (Table 3) showed that the group with the lowest average number of muscle fibers (44.91) also had the highest ADG, while the group with the highest number of muscle fibers (91.11) was characterized by the highest DFI as well as FCR.

When evaluating the muscle fibers area, the group of pigs with the largest average fiber area (9567 µm²) showed the lowest DFI and low FCR. When comparing the obtained results in the ham and loin, it could be stated that for both carcass parts the same trend was observed.

OKSBJERG et al. (2000) dealt with growth potential in Danish Landrace breed. The observations were carried out for the MLLT muscle and their final results state that pigs with a higher ADG (as compared with the pigs with lower ADG) had a smaller muscle fibers area and a higher muscle fibers number per area unit. ORZECHOWSKA, WOJTYSIAK (2008) evaluated the correlation between MLLT fiber characteristics in Polish Landrase, Polish Large White and Pietrain and ADG. They found a positive correlation between the fiber number, area and ADG. Increased ADG results in positive change in the muscle fibers size. However this finding could not be confirmed by our results.

Table 2. Fattening characteristics of the monitored groups with regards to the muscle fibers number and area in the ham

Ham (MS)	Group 1				Group 2				Group 3				Significance		
	x	s	Min.	Max.	x	s	Min.	Max.	x	s	Min.	Max.	**	*	*NS*
Muscle fibers frequency	**46,39**	**5,62**	**32,00**	**56,00**	**67,57**	**4,61**	**59,00**	**75,00**	**90,62**	**14,62**	**76,00**	**124,00**			
ADG (g)	919	69	803	1038	891	103	753	1141	900	48	836	969	1-2, 1-3	2-3	
DFI (kg)	2,68	0,34	2,01	3,22	2,64	0,35	1,98	3,22	2,63	0,31	2,10	3,11	1-2, 1-3		2-3
FCR (kg)	2,63	0,27	2,21	3,34	2,75	0,24	2,30	3,22	2,79	0,24	2,39	3,32			1-2, 1-3, 2-3
Muscle fibers area (µm²)	**3078**	**819**	**508**	**4262**	**5529**	**786**	**4264**	**7052**	**9454**	**1908**	**7058**	**17956**			
ADG (g)	902	77	753	1141	915	91	753	1141	883	80	753	1141	1-3, 2-3		1-2
DFI (kg)	2,64	0,33	1,98	3,22	2,65	0,37	1,98	3,22	2,63	0,31	1,98	3,22	2-3		1-2, 1-3
FCR (kg)	2,71	0,25	2,21	3,34	2,74	0,27	2,21	3,34	2,71	0,25	2,21	3,34			1-2, 1-3, 2-3

** differences between the averages are statistically significant (P < 0,01), * differences between the averages are statistically significant (P < 0,05), NS – inconclusive differences

Table 3. Fattening characteristics of the monitored groups with regards to the muscle fibers number and area in the loin

Loin (MLLT)	Group 1				Group 2				Group 3				Significance		
	x	s	Min.	Max.	x	s	Min.	Max.	x	s	Min.	Max.	**	*	**NS**
Muscle fibers frequency	**44,91**	**5,71**	**33,00**	**54,00**	**63,27**	**5,65**	**55,00**	**73,00**	**91,11**	**10,02**	**82,00**	**112,00**			
ADG (g)	925	83	810	1141	909	96	753	1074	920	85	784	1073	1-2, 1-3, 2-3		
DFI (kg)	2,41	0,36	2,01	3,22	2,53	0,34	1,98	3,22	2,69	0,34	2,16	3,13	1-2, 1-3, 2-3		
FCR (kg)	2,59	0,20	2,30	3,06	2,78	0,27	2,30	3,34	2,92	0,22	2,45	3,32			1-2, 1-3, 2-3
Muscle fibers area (µm²)	**3068**	**726**	**632**	**4199**	**5487**	**816**	**4202**	**7028**	**9567**	**2054**	**7035**	**17722**			
ADG (g)	937	86	753	1141	939	87	753	1141	936	96	753	1141			1-2, 1-3, 2-3
DFI (kg)	2,56	0,35	1,98	3,22	2,53	0,37	1,98	3,22	2,48	0,37	1,98	3,22	1-3		1-2, 2-3
FCR (kg)	2,77	0,25	2,30	3,34	2,74	0,28	2,30	3,34	2,74	0,28	2,30	3,34	1-3	1-2	2-3

** differences between the averages are statistically significant (P < 0,01), * differences between the averages are statistically significant (P < 0,05), NS - inconclusive differences

Conclusion

It has been demonstrated that for the carcass parts of ham and loin, in the terms of muscle fibers characteristic and monitored growth intensity, the animals with lowest values of muscle fiber qualitative parameters (area) showed the lowest average daily gain and the lowest daily feed consumption. In terms of the feed conversion no general trend could be demonstrated. Regarding the number of muscle fibers there was no significant trend found in relation to the monitored fattening performance indicators.

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