Influence of pig genotype on histochemical properties of longissimus dorsi muscle and some carcass and meat quality traits

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Background

Many studies suggest that muscle characteristics and partriculary fibre type frequency may explain part of the variation in some meat quality characteristics (Kłosowska, 1972, Cassens et al. 1975, Kłosowska, 1984, Sośnicki, 1987, Essen-Gustavsson et al. 1992, Fiedler et al. 1993, Larzul et al. 1997, Henckel et al. 1997). In pig muscles, slow twich fibres (Type I) have a higher aerobic capacity, a lower glycolytic capacity, and contain a greater content of intracelluar lipid and myoglobin than fast-twich fibres (Type II) (Essen-Gustavsson et al. 1994). Longissimus muscle is the most frequently used indicator in meat quality studies in pigs. This muscle contains a higher percentage of Type II fibres, especially Type II B fibres, and has a low oxidative capacity (Lundström et al. 1989). The proportion of fibre types in a muscle, their metabolic profile and recruitment pattern, are probably important factor that might determine the extent of glycogenolysis and lactate formation at slaughter. It has been shown that fibre area increases with intensity of selection in domestic pigs, while the proportion of oxidative fibers decreases (Kłosowska, 1972, Rede et al. 1986). Lowering of pH and reduced water holding capacity in intensely selected pigs such as Yorkshire and Landrace are related to the large proportion of non-oxidative fibres in these breed (Rede et al. 1986). According to Essen-Gustavsson and Fjelkner-Modig (1985) muscle oxidative capacity affects meat quality by improving the sensory properties of meat. It is necessary to notice that some breed with high content of the meat as Hampshire pigs have the muscles which are more oxidative than the muscles of Landrace or Yorkshire pigs. Hampshire sires lastly were used in Poland for crossbreeding with Polish Landrace x Large White x Duroc. These threeway crosses have been used for pig production in Poland.

Objectives

The objective of this study was to compare histochemical properties of longissimus muscle and some carcass and meat quality characteristics in pig crosses with the share of Hampshire breed.

Methods

The experiment comprised of 90 pigs, 100 kg live weight each. The pigs were divided into three groups of 30 pigs in each. The pigs were kept at the same enviromental conditions and were fed with full batch feed. The research was carried out on crosses of white sows Polish Large White (PLW) x Polish Landrace arranged into the following three groups:

C - (PLW x PL) x (PLW x PL)
HD - (PLW x PL) x (Hampshire x Duroc)
H - (PLW x PL) x Hampshire

To histological examinations the muscle samples were taken from the middle part of m. longissimus lumborum near 45 min. post mortem. The samples were frozen in liquid nitrogen to the time of analysis. The muscle samples were cut in cryostat on 10 µm thicks sections and subjected to double reaction for activity of NADH-TR oxidoreductase and myofibrillar ATPase after acid preincubation (Wegner et al. 1993). Slow twich oxidative (STO), fast twich oxidative (FTO), fast twich glycolytic (FTG) fibers were identified according to Wegner et al. (1993). Ten fields containing of each fiber types were randomly chosen to evaluate the proportion, muscle fibre diameters and the average cross sectional area of all fibers of the same type using a computerized image analysis system Leica Q 500 MC. The pH value was determined 45 minutes (pH_1) and 24 hours (pH_2) post mortem with use of Radiometer PHM-80 Portable pH-meter equipped with combined elektrode. WHC (water holding capacity) determined according to Grau and Hamm (1952). Meat content in the carcass was determined both by apparatus Ultra-Fom (Borzuta et al. 1997a) and by apparatus of Dramiński firm (Borzuta et al. 1997b). The data were analyzed statistically by using analysis of variance.

Results and Discussion

In this study it was shown that the percentage of STO fibers was on the same level in three groups of pigs. Only group H showed higher percentage of FTO fibers and lower FTG fibers (Table 1). The muscle fiber type composition group C in this experiment differed from that one in the boars and gilts of pure Polish Landrace breed. The percentage of STO fibers (13,2%) and FTO (14,8%) were higher and FTG fibers (72,0%) was lower (Kłosowska et al. 1994). In the cross-sectional area of all fibers of the same type also obtained similar differences between groups as in muscle fiber percentage. M. longissimus dorsi of group H contained larger cross-sectional area of STO and FTO fibers than groups C and HD (Table 1). Also Ruusunen and Puolanne (1997) found larger cross-sectional area of I and II A fibers and smaller II fibers in Hampshire pigs than in Finnish Landrace and Finnish Yorkshire. Also in this study significant differences in some muscle fiber diameter related with genetic group were noticed (Table 1). Any differences were noticed between groups in diameters of STO fibers but FTO fibers were the greatest in group H and FTG fibers in group H and HD. The least FTG fibers showed group C. Longissimus muscle pH_1 didn't differ between examined groups. Longissimus muscle ultimate (pH_2) was lower and water-holding capacity was worse but greater content of meat in the carcasses ($p<0,01$) was found in the genetic groups with the share of Hampshire breed (Table 2). According to Przybylski et al. (1995) meat of Hampshire breed showed higher glycolytic potential, lower ultimate pH and also technological yield of meat characteristic for animals wich showed „acid meat". These microstructural results show some influence of the Hampshire boars in the breed crosses on the increase of muscle fiber diameters as well as on the increase of relative areas of oxidative muscle fiber types.

Conclusions

1. Pig genotype with the higher share of Hampshire breed showed greater content of oxidative muscle fiber type, greater area of these fibers and greater diameters of the all fiber types, than breed crosses Polish Landrace and Polish Large White.
2. The crossbreeds with Hampshire breed showed more meat content in the carcass, lower pH_2 and lower water-holding capacity in comparison to crossbreed of Polish Landrace and Polish Large White.

Pertinent literature

1. Borzuta K., Piechocki T., Powałowski K., Strzelecki J., Trzoda Chlewna 4, 80-82, 1997.
2. Borzuta K., Strzelecki J., Piechocki T., Powałowski K., Piotrowski E., Trzoda Chlewna 2, 25-27,1997.
3. Cassens R.G., Marple D.N., Eikelenboom G., Adv. Food. Res. 21, 71-155 , 1975.
4. Essen-Gustavsson B., Fjelkner-Modig S., Meat Science 13, 33-47, 1985.
5. Essen-Gustavsson B., Karlström K., Lundström K., Meat Science 31, 1-11, 1992.
6. Essen-Gustavsson B., Karlsson A., Lundström K., Enfält A.C., Meat Science 38, 269-277, 1994.
7. Essen-Gustavsson B., Lindholm A., Comparative Biochemistry and Physiology, 78A, 67-71, 1984.
8. Fiedler I., Ender K., Wicke M., von Lengerken G., Arch. Tierz., Dummerstorf 36, 5, 525-538, 1993.
9. Grau R., Hamm R., Fleischwirtschaft, 4, 295-297, 1952.
10. Henckel P., Oksbjerg N., Erlandsen E., Barton-Gade P., Bejerholm C., Meat Science, 47, 311-321, 1997.
11. Kłosowska D., Zesz. Probl. Post. Nauk. Rol. 139, 199 - 205, 1972.
12. Kłosowska D., Histological and histochemical characteristics of muscles in pigs, cattle and poultry and their relationship with meat quality., BTN, Prac. Wydz. Nauk Przyrod. Seria B, Rozp. habil., 31, 1 - 123, 1984
13. Kłosowska D. , Kłosowski B., Kapelański W., Wegner J., IInd Intern. Conf. „The influence of genetic and non genetic traits on carcass and meat quality." Siedlce, 7 - 8 November 1994, Proceed. 218 - 223, 1994.
14. Larzul C., Lefaucher L., Ecolan P., Gouge J., Talmant A., Sellier P., Le Roy P., Monin G. J. Anim. Sci. 75, 3126 - 3137, 1997.
15. Lundström K., Essen-Gustavsson B., Rundgren M., Edfors-Lilja I., Malmfors, Meat Science 25, 251-263, 1989.
16. Przybylski W., Kocwin-Posiadła M., Kaczorek S., Krzęcio E., Naveau J., Tyszkiewicz I. 41st An ICOMST. Proceed. Vol. II, 104-105, 1995.
17. Rede R., Pribisch V., Rahelic S. Fleischwirtsch. 66, 5, 898-907,1986.
18. Ruusunen M., Puolanne E. Meat Sci. 45,1,119-125,1997.
19. Sośnicki A. J. Anim. Sci. 64, 1412-1418, 1987.
20. Wegner J., Fiedler I., Kłosowska D., Kłosowski B., Ziegan B., Anat. Histol. Embryol. 22, 355-359, 1993.

Table 1
Histological traits in the longissimus dorsi of three genetic groups of pigs

Traits		Breeding group					
		C		HD		H	
		x	S	x	S	x	S
Fibre type, %	STO	9,70±3,70		9,23±3,44		9,95±3,50	
	FTO	$12,18^{A}$±4,11		$13,93^{A}$±4,63		$17,09^{B}$±6,50	
	FTG	$78,60^{A}$±5,17		$76,82^{A}$±4,68		$72,12^{B}$±7,67	
Relative areas, %	STO	7,89±3,08		8,00±3,28		8,20±3,36	
	FTO	$11,67^{A}$±5,55		$9,96^{A}$±3,25		$15,45^{B}$±7,01	
	FTG	$80,45^{A}$±5,70		$82,04^{A}$±4,31		$76,34^{B}$±6,91	
Fibre diameters, µm.	STO	68,83±5,64		70,70±8,07		73,08±7,21	
	FTO	$66,27^{A}$±7,37		$64,26^{AB}$±6,11		$72,27^{B}$±8,71	
	FTG	$77,71^{A}$±5,44		$83,72^{B}$±6,50		$80,56^{AB}$±7,19	

Significant differences between means are signed with the different letter A, B - $p<0,01$

Table 2
Quality characteristic of meat from evaluated breeding groups (n=30)

Traits	Statistic items	Breeding group		
		C	HD	H
pH_1	x	$6,56^{A}$	$6,65^{A}$	$6,62^{A}$
	S	0,33	6,20	0,23
pH_2	x	$5,94^{A}$	$5,67^{B}$	$5,72^{B}$
	S	0,09	0,12	0,11
WHC, (% loss)	x	$33,71^{A}$	$35,95^{B}$	$39,07^{C}$
	S	2,03	2,70	1,94
Meat content in carcass, % (Dramiński)	x	$48,07^{A}$	$55,03^{B}$	$55,20^{B}$
	S	5,99	3,09	4,48
Meat content in carcass, % (Ultra-Fom)	x	$50,66^{A}$	$55,01^{B}$	$55,61^{B}$
	S	5,36	3,08	4,28

Significant differences between means are signed with the different letters A,B- $p<0,01$