THE INFLUENCE OF MUSCLE FIBRE AREA ON PORK QUALITY

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Abstract. Meat quality is one of the important factors in pork production. A better control of meat quality is of major importance for producers and retailers in order to satisfy the consumer's requirement for a consistently good product. Muscle fiber characteristics are thought to be important factors influencing meat quality however, identifying a strong correlation between fiber types and meat quality remains to be established. The objective of the study was to demonstrate the influence of pork *m. longissimus dorsi fibre* area on meat quality indexes and to establish correlations. It was determined that Large White pigs had the biggest fibre area - 2281 μm^2 and Landrace pigs had the smallest fibre area - 1871 μm^2 ($p<0.05$). The correlation between fibre area and drip loss was statistically significant ($p<0.05$). Pork with the biggest fibre area had the highest shear force, drip loss and cooking loss. The results showed that pig *m. longissimus dorsi fibre* area has the influence on meat quality, especially on meat drip loss, shear force and cooking loss.
Key words: muscle fibre, muscle fibre area, meat quality, pork.

RAUMENS SKAIDULŲ PLOTO ĮTAKA KIAULIENOS KOKYBEI

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Santrauka. Vienas svarbiausių kiaulienos produkcijos veiksnių yra jos kokybė. Geresnė mėsos kokybės kontrolė – svarbiausias uždavinys gamintojams ir perdirbėjams tenkinant vartotojų gero produkto reikalavimus. Raumens skaidulos yra vienas svarbiausių histologinių faktorių, veikiančių mėsos kokybę. Tačiau stipri koreliacija tarp skaidulų tipo ir mėsos kokybės vis dar turi būti nustatyta. Šio darbo tikslas – nustatyti ilgiausiojo nugaros raumens skaidulų ploto įtaką kiaulienos kokybei bei nustatyti koreliacinį ryšį.

Nustatyta, kad didžiosios baltosios kiaulės turėjo didžiausią skaidulų plotą – 2281 μm^2, o landrasų veislės kiaulių jis buvo mažiausias – 1871 μm^2 ($p<0,05$). Tarp skaidulų ploto ir vandeningumo nustatytas teigiamas koreliacinis ryšys ($p<0,05$). Kiaulienos, turinčios didžiausią skaidulų plotą, kietumas, vandeningumas ir virimo nuostoliai taip pat buvo didžiausi. Tyrimai parodė, kad ilgiausiojo nugaros raumens skaidulų plotas turi įtakos mėsos kokybei, ypač vandeningumui, kietumui ir virimo nuostoliams.
Raktažodžiai: raumens skaidulos, skaidulų plotas, mėsos kokybė, kiauliena.

Introduction. Meat quality is one of the important factors in pork production. A better control of meat quality is of major importance for producers and retailers in order to satisfy the consumer's requirement for a consistently good product (Piccard et. al., 2002). Big variety of pig breeds allows choosing the most optimal breeding combinations by selection not only according to the growth speed, muscularity and feed input, but according to the meat quality, as well (Moelich et al, 2003). Selection of pigs has the main role of improving pork quality (Jukna et al., 2004).

Understanding of skeletal muscle growing and development is one of the most important aims in animal husbandry and for improving meat quality (Rehfeld et al., 1999). The *longissimus dorsi* is one of the muscles most frequently utilized for pork quality evaluation because of its high commercial value, size and ease of access for sampling (Migdal et al., 2005; Bertol et al., 2006). The major component of muscle is the constituent muscle fibres (Te Pas M. F. W. et al, 2004). Muscle fibre is one of the most important histological factors affecting meat quality (Oksbjerg et al., 2000; Rehfeldt et al., 2000; Nissen et al., 2004). Muscle fibre area is important factor affecting numerous pre- and post-mortem biochemical processes and thus also meat quality (Klosowska, Fiedler, 2003). It is established that muscle fibre characteristics is involved in meat tenderness and taste. One of the main factors affecting muscle mass differences obtained from animal selection and breeding is muscle fibre size (Rehfeld et al., 1999). There are suggestions that including muscle fibre characteristics in breeding programmes may improve meat quality (Klosowska, Fiedler, 2003).

However, a direct effect of fiber size on meat quality remains unclear. This may be, in part, due to indirect effects of muscle fiber type on meat quality through differences in associated muscle components, such as sarcoplasmic proteins, muscle enzymes, intramuscular fat, and connective tissue (Lefaucheur, Gerrard, 1998).

The objective of the study was to demonstrate the influence of fibre area from pork *m. longissimus dorsi* fibre on meat quality indexes and to establish correlations.

Materials and methods. Meat characteristics and quality evaluation was held at the State Breeding Station of Pigs under standard feeding and keeping conditions in Lithuania, at the Laboratory of Meat Characteristics and Quality Assessment at Lithuanian Veterinary Academy.

Target figure was to determine meat quality from pigs and its histological, technological and biologic features. A total of three breeds: 20 Lithuanian White (LTW), 20 Large White (LW) and 20 Landrace (L) pigs were used. Meat characteristic and quality was evaluated of 20 pigs from each breed (10 sows and 10 boars from each breed).

All pigs were kept under the same standard feeding and keeping conditions and slaughtered at the same slaughtering house just at the different time. Pigs were slaughtered when they reached 95 kg weight. 500-550 g samples from *m. longissimus dorsi* for the investigation of meat quantitative indexes were taken 24 hours after slaughtering. Meat quantitative indexes were determined at the Laboratory of Meat Characteristics and Quality Assessment at Lithuanian Veterinary Academy 36 hours after slaughter. Evaluation of meat quality was carried out for to fix: meat pH, meat colour, dry matter, meat toughness, water holding capacity, cooking loss, fat and protein amount. The amount of dry matter was measured by the automatic scale for humidity assessment Scaltec SMO – 01, drying samples at 105ºC, pH – by a pH-meter Inolab 3, by a contact electrode (pH ISO 2917:1999 Meat and meat products measurement of pH). Meat color by a Minolta Chroma Meter 410, measuring L* values for lightness, a^* values for redness and b^* values for yellowness, fat – by an automatic system for fat extraction Soxterm SE 416 macro (ISO 1443:1973 Meat and meat products determination of total fat content), ash – by organic matter incineration at 700ºC (ISO 936:1998 Meat and meat products determination of total ash), protein according to Kjeldal method. Drip loss was measured by a bag method, the meat was kept in special bags for 24 hours at + 4ºC temperature, water holding capacity was defined according to Grau and Hamm, cooking loss packaged under vacuum - in a circulating water bath at 75ºC temperature for 30 min., meat tenderness – according to Warner – Bratzler. The samples were stored at -80ºC until analysis.

Analysis of muscle histology was carried out at the Laboratory of Meat Quality, Faculty of Life Sciences, University of Copenhagen, Denmark (former Royal Veterinary and Agriculture University), as follows.

Plastic embedding and sectioning. Samples were cut into pieces of approximately 0.5 x 1 x 1.5 cm and fixed in 30 ml of 4% buffered formaldehyde (ACROS, Belgium) 100ml mM MES, 0.9% NaCl (Merck, Darmstadt, Germany). The fixed samples were washed in mili-Q-water and dehydrated in a series of ethanol, 99% ethanol mixed 1:1 with Technovit 7100 (KULZER, Werheim, Germany), and Technovit 7100, then with 10 ml Technovit 7100 + 1g hardener I and 10 ml Technovit 7100 + hardener I with 500 µm of hardener II. Subsequently, samples were embedded in Technovit 3040 and cut at 3 µm thickness on a RM2155 Microtome (LEICA, Nussloch, Germany) using a metal d-knife. Sections were stained with Orange G, Acid Fuchsin and Aniline Blue pH 2.5. Pictures of the areas on a section were taken on a Leica DM IRB microscope with a high resolution CCD camera (Cool Snap, Roper Scientific Inc., USA) and analyzed with Image-Pro Plus software (Image House, Denmark). 10 pictures from each sample were analyzed.

The data was analyzed by using statistical R pack version 2.0.1 (Gentlemen, Ihaka, 1997).

Results and discussion. Muscle fibre area is important factor affecting numerous pre- and post-mortem biochemical processes and thus also meat quality (Klosowska & Fiedler, 2003). Meat quality and histological indexes are presented in Table 1.

Table 1. **Meat quality indexes and fibre area from different pig breeds**

Index		Breed		
		Lithuanian White	Large White	Landrace
Dry matter, %		25.28±0.17	24.79±0.19	25.64±0.38
pH		5.79±0.23	5.48±0.05	5.44±0.01
Color:	L*	54.41±2.28	55.39±1.32	57.03±1.08
	a*	14.07±0.37	13.73±0.36	13.47±0.45
	b*	5.75±0.69	6.14±0.28	6.95±0.54
Drip loss, %		4.73±0.73	10.47±1.33	7.26±0.79
Water-holding capacity, %		54.35±3.27	50.62±1.38	50.85±1.08
Cooking loss, %		23.49±3.19	29.19±1.17	28.45±1.44
Shear force, kg/cm^2		1.59±0.24	1.85±0.10	1.82±0.30
Intramuscular fat, %		1.52±0.21	1.12±0.21	1.51±0.28
Protein, %		22.61±0.17	22.43±0.16	22.97±0.26
Ash, %		1.15±0.02	1.24±0.02	1.16±0.01
Fibre area, µm^2		2030±100	2281±91	1871±130
Gaps among fibre, µm		48±4	41±5	40±7

Analysis of histological indexes has shown that LTW pigs had the biggest fibre area and Landrace pigs had the smallest fibre area and the difference between them was 410 µm^2 ($p<0.05$). Also gaps among fibre differences were determined. L pigs had the smallest gaps among fibre and LTW pigs had the biggest gaps and the difference between them was 8 µm. LTW pigs had the biggest gaps among fibres, but their meat drip loss was the lowest in comparison with the other breeds. This could be explained with high amount of intramuscular fat and the highest water holding capacity in LTW pig meat in comparison with the other pig breeds.

LW pig meat had the biggest fibre area and the biggest shear force in comparison with the other breeds. The tendency was observed that pork with the biggest fibre area had the highest drip loss and cooking loss.

LW pig meat had the highest drip loss and LTW pig meat had the lowest drip loss and the difference between them made 5.74 % ($p<0.01$). The difference of drip loss between LW and L pig meat was 2.53 % ($p<0.05$).

LW pig meat had the highest and LTW pig meat had the lowest ash amount and the difference between them made 0.09 % ($p<0.01$). Ash amount's difference between LW and L pig meat was 0.08 % ($p<0.05$).

Establishing relationships among specific quality traits is important if significant progress toward developing improved pork quality is to be realized (Huff-Lonergan E. et al., 2002). Some meat quality traits were evaluated in an attempt to assess meat quality of the selected breeds. Some of these include Hunter L-values, meat pH, drip loss and cooking loss. There were significant correlations among many of the quality traits (Table 2).

Table 2. **Correlations among important pork quality traits**

	Fibre area, μm ^{2}	Gaps among fibre, μm	pH	L*	a*	b*	Drip loss, %	Water-holidng capacity, %	Cooking loss, %
Gaps among fibre, μm	-0.11								
pH	-0.26	-0.05							
L*	0.16	-0.26	**-0.74****						
a*	-0.23	0.26	-0.03	-0.29					
b*	-0.21	-0.40	**-0.49***	**0.76****	-0.07				
Drip loss, %	**0.48***	-0.22	**-0.56***	0.43	-0.16	0.39			
Water-holding capacity, %	-0.20	-0.06	**0.77****	**-0.62****	-0.16	**-0.56***	**-0.48***		
Cooking loss, %	0.36	0.07	**-0.89****	**0.55***	0.19	0.29	**0.60****	**-0.76****	
Intramuscular fat, %	-0.18	0.20	-0.09	0.13	0.28	0.11	-0.28	-0.37	0.04

Bold values indicate significant correlations: * $p<0.05$; ** $p<0.01$.

Fibre area was significantly correlated with drip loss ($p<0.05$). These results indicate that meat with the biggest fibre area had the highest drip loss.

Meat pH (at 48h post mortem) was highly correlated ($p<0.01$) with lightness L*, water holding capacity and cooking loss. Meat pH was significantly correlated ($p<0.01$) with yellowness b* and drip loss ($p<0.05$).

Meat lightness L* was significantly correlated with yellowness b*, water-holding capacity and cooking loss ($p<0.01$). These data indicate that meat with the highest L* value had the highest b* value.

Drip loss was statistically significantly correlated with drip loss and water holding capacity ($p<0.05$). In this study, meat with the highest drip loss value had a tendency to loose less weight during cooking. This in not surprising, as moisture lost prior to cooking obviously could not be lost during cooking.

The high correlation between water-holding capacity and cooking loss was statistically significant ($p<0.01$). Meat with the highest water-holding capacity had the lowest cooking loss and meat with the lowest water-holding capacity had the highest cooking loss.

Conclusions. LW pigs had the biggest fibre area and L pigs had the smallest fibre area ($p<0.05$). LW pig meat has the highest shear force, drip loss and cooking loss. Pork muscle fibre area has influence on meat quality, especially on drip loss ($p<0.05$), shear force and cooking loss. LTW pigs had the biggest gaps among fibres, but their meat drip loss was the lowest in comparison with the other breeds. This could be explained with high amount of intramuscular fat and the highest water holding capacity in LTW pig meat in comparison with the other pig breeds.

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