REGION - DEPENDENT VARIATIONS OF FIBRE TYPE COMPOSITION AND FIBRE SIZE IN LONGISSIMUS MUSCLE OF PIG

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BACKGROUND AND OBJEKTIVES

The *Longissimus* muscle of pig is often used for investigations of morphological, physiological, and pathological effects. Moreover, it is used for studies of factors which influence meat quality. Currently, knowledge about topographical differences in fibre size and fibre type composition in pigs is rare. Variations in muscle fibre characteristics, intramuscular fat content, and enzyme activities of different muscles and species were described (Martin et at.,1988; Horak, 1988, 1995; Wicke et al., 1994, 1997), suggesting that these factors can determine muscle heterogenity. On the other hand, variations in muscle fibre properties can be considered to cause differences in meat quality (Essen-Gustavsson et al., 1992; Henckel et al., 1997; Fiedler et al.,1997).
The aim of the study was to investigate muscle fibre characteristics in different regions of *Longissimus* muscle: 1. to characterize the fibres in two neighbouring regions of a single biopsy sample taken from superficial part of muscle (experiment I), 2. to compare central and deep/near-bone parts of muscle at location 13th/14th rib (experiment II), 3. to analyse three regions along the longitudinal axis (experiment III) at locations 11th/12th thoracic vertebrae (cranial, CR), 13th/14th rib (middle, MI), and 5th/6th lumbar vertebrae (caudal, CA).

MATERIAL AND METHODS

In this study 96 gilts and castrates of the genotype Pietrain x (Large White x German Landrace) were used. The average carcass weights of the animals were 40 and 105 kg, respectively. In experiment I, samples were taken by shot biopsy (Schöberlein, 1989) from *Longissimus* muscle of animals two days before slaughter and in experiments II and III they were taken by autopsy 45 min after slaughter. Muscle samples of approximately 6 x 6 x 8 mm were quickly frozen in liquid nitrogen. Transversal sections of 10 µm thickness were stained for NADH tetrazolium reductase and combined NADH tetrazolium reductase / ATPase reactions (Fiedler and Weber, 1981; Rehfeldt and Ender, 1993). Microscopical data were obtained by counting of fibre numbers per type and by measuring the Crumbein`s diameters of 400 fibres per section. From this population frequencies of fibre types and cross sectional areas of fibres were calculated. As result of enzyme histochemical reactions, fibre types were classified as "red", "intermediate", "white" and slow twitch oxidative (STO), fast twitch oxidative (FTO), fast twitch glycolytic (FTG), respectively. All data were determined semi-automatically by a computer-aided muscle fibre analyzer (Beyersdorfer et al., 1985). They were subjected to Student`s t-test to evaluate differences between regions. Significances were marked by $p < 0.05$.

RESULTS AND CONCLUSIONS

The data of fibre size and fibre type composition in different regions of *Longissimus* muscle are presented in Tables 1 to 3. The *Longissimus* muscle consists mainly of white fibres and only a small numbers of red and intermediate fibres. This characteristic composition was observed in all regions, but variations were found between the regions within this spectrum.

Differences between two neighbouring regions within a single biopsy sample (Table 1)
As documented in Table 1, fibre type composition was the same in samples A and B, but fibre cross areas were different. In both groups of 40 kg and 105 kg of carcass weights muscle fibres which were located immediately under subcutanous fat were bigger in size than fibres which were located under them. During growth a decrease of the oxidative "red" and "intermediate" fibre type proportions and an increase of glycolytic "white" fibre type were observed. As expected, fibre sizes increased nearly twofold during this period of growth. In conclusion, location of biopsy samples for analysis of muscle structure traits must be defined exactly for each animal, and it is important that the samples n the samples are taken in the same region as exact as possible.

Changes along the transversal axis from central to deep / near-bone region (Table 2)
Distribution patterns of fibre type frequencies and fibre sizes are shown in Table 2. Thus, an higher percentage of red / STO type and a lower percentage of white / FTG type were found in the region located near the bone compared to the central region. The difference in the percentage of intermediate / FTO type was not significant. Both of the used histochemical methods of fibre type classification showed similar results with regard to fibre type composition and fibre size. This high identity of metabolic and contraction properties of fibres are typical for *Longissimus* muscle (Salomon et al., 1986). No differences were observed in fibre size between regions. The results indicate region-dependent differences between central and deeper part of muscle. Causal relationships between variations in fibre type composition, fibre size, fat cell size, and parameters of meat quality traits were found in previous experiments (Wegner and Ender, 1990; Wicke et al., 1994).

Changes along the longitudinal axis from cranial to caudal region (Table 3)
The population of STO fibres showed a significant increase by 65 % from the region of thoracic vertebrae to the region of lumbar vertebrae. The FTG fibres decreased by 14 %. Only the difference of STO fibre type was significantly between the cranial and the middle and the caudal region. Muscle fibre cross section areas of all fibre types increased along the longitudinal axis of *Longissimus* muscle. Marked differences were observed in fibre areas of STO fibre type (29 %), FTO fibre type (26%), and FTG fibre type (22 %) between the cranial to the middle regions. Fibre sizes increased somewhat but not significantly between middle and cranial region.
The results suggest an influence of the region on muscle fibre characteristics. In a previous experiment relationships between parameters of muscle structure, muscle function and meat quality dependent on region was found (Wicke et al, 1997). Differences were found in colour brightness, sensory traits and intramuscular fat content.
In conclusion, an exact standardisation of measuring points is necessary to guarantee the comparability of the data.

LITERATURE
Beyersdorfer, G.; Ohlerich, M.; Wegner, J.: Z. mikr.-anat. Forsch. 99 (1985), 671 - 675
Essen-Gustavsson, B.; Karlström, K.; Lundström, K.: Meat Sci. 31 (1992), 1 - 11
Fiedler, I.; Weber, C.: Z. mikr.-anat. Forsch. 95 (1981), 1027 - 1034
Fiedler, I.; Rehfeldt, C.; Dietl, G.; Ender, K.: J. Anim. Sci. 75 (1997), Suppl.1, 165
Henckel, P.; Oksbjerg, N.; Erlandsen, E.; Barton-Gade, P.; Bejerholm, C.: Meat Sci. 47 (1997), 311 - 321
Horak, V.: Reprod. Nutr. Dev. 35 (1995), 725 - 736
Rehfeldt, C.; Ender, K.: Meat Sci. 34 (1993), 107 - 118
Rao, M.V.; Gault, N. F.: Meat Sci. 26 (1989), 5 - 18
Salomon, F.-V., Fiedler, I.; Ziegan, J.; Heinz, M.: Mh. Vet. Med. 41 (1986), 156 - 158
Schöberlein, L.: Arch. Tierz. 32 (1989), 235 - 244
Wegner, J., Ender, J.: Fleischwirtsch. 70 (1990), 337 - 340
Wicke, M.; Lengerken, G. v.; Fiedler, I.; Heylen, K.: Tag.-bericht 3.Tagung Schweine- und Geflügelernährung, 29. 11.-1. 12. 1994, Halle/Saale
Wicke, M.; Heylen, K.; Maak, S.; Lengerken, G. v.: Proc. 43th ICOMST, July 27 to Sept 1 (1997) Auckland, New Zealand, 626 - 627

Table 1: Comparison of neighbouring regions A and B within a single biopsy sample
A: underneath subcutanous fat; **B**: underneath sample A
Reaction: NADH-TR (Fiedler u. Weber, 1981); n = 80
First value: carcass weight of 40 kg; **Second value**: carcass weight of 105 kg

		x A	s	x B	s	Significance
Fibre type composition (%)	**Red**	**11.7**	3.4	**11.2**	3.0	n s
		10.1	3.1	**9.9**	2.8	n s
	Intermediate	**15.3**	3.5	**15.1**	3.2	n s
		13.9	3.1	**13.8**	3.4	n s
	White	**73.0**	4.2	**73.7**	4.1	n s
		76.0	4.1	**76.3**	4.1	n s
Fibre cross area (µm²)	**Red**	**3019**	588	**2765**	670	n s
		5469	1727	**4852**	1320	n s
	Intermediate	**3078**	790	**2563**	597	s
		5192	1373	**4257**	772	s
	White	**4245**	941	**3254**	830	s
		8009	1255	**6047**	855	s

Table 2: Fibre traits in central (CE) and deep / near-bone regions (DE) within Longissimus muscle cross section
First value: NADH-TR reaction (Fiedler and Weber, 1981) **n** = 16
Second value: combined NADH-TR / ATPase reaction (Rehfeldt and Ender, 1993)

		x CE	s	x DE	s	Significance
Fibre type composition (%)	**Red**	**10.4**	2.1	**14.0**	3.9	s
	STO	**8.8**	1.7	**12.4**	4.3	s
	Intermediate	**13.5**	2.4	**15.2**	2.4	n s
	FTO	**15.5**	1.6	**15.1**	2.8	n s
	White	**75.9**	0.5	**70.6**	4.1	s
	FTG	**75.6**	0.2	**72.2**	4.8	s
Fibre cross area (µm²)	**Red**	**2580**	807	**2668**	498	n s
	STO	**2933**	615	**3073**	506	n s
	Intermediate	**2228**	339	**2611**	692	n s
	FTO	**2104**	360	**2656**	826	n s
	White	**4016**	455	**4256**	653	n s
	FTG	**4039**	232	**4337**	826	n s

Table 3: Distribution of fibre traits along the longitudinal axis of *Longissimus* muscle
Reaction: combined NADH-TR / ATPase ; **CR** = cranial; **MI** = middle; **CA** = caudal **n** = 16

		x CR	s	x MI	s	x CA	s
Fibre type composition (%)	**STO**	**6.77**	2.79	**10.36**	3.14	**11.20**	3.34
	FTO	**16.30**	2.53	**16.91**	3.61	**14.06**	2.73
	FTG	**76.83**	4.28	**72.67**	5.53	**74.57**	4.44
Fibre area (µm²)	**STO**	**2371**	233	**3067**	634	**3054**	390
	FTO	**1703**	409	**2150**	587	**2367**	335
	FTG	**3371**	866	**4126**	829	**4322**	498

NOTES