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TOTAL MUSCLE FIBRE NUMBER IN M. LONGISSIMUS OF LIVE PIGS-RELATIONSHIPS TO STRESS SUSCEPTIBILITY AND MEAT QUALITY

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Keywords: pig; meat quality, stress susceptibility; muscle fibre number, muscle structure

Background

Breeding for high meat yield in pigs can lead to higher stress susceptibility as well as poorer meat quality. To eliminate this deficiency, relations between meat quality, stress susceptibility and mutations at the ryanodine receptor were used. Another starting point to prevent the occurrence of poor meat condition, is to element the problem at the site of the muscle. In former tests it was found, that a large diameter or a low percentage of oxidative fibres is connected with bad meat quality. This indicates that it is better to realize high meat yield by a lot of thin fibres than by a low number of thick fibres (Fiedler et al., 1993, Wicke et al., 1991). Taking into account that the number of fibres is genetically determined and the post-natal muscle growth is caused nearly exclusively by hypertrophy, it should be emphasized that the total number of muscle fibres created during myogenesis is an important factor for the growing potential of muscles p.p.. Therefore, high meat yield combined with good meat quality is best realized by a high total number of muscle fibres (MFN_T) and physiologically favorable fibre diameters. Until now it has not been possible to use these findings for breeding, because of the difficulties in measuring the total number of muscle fibres in living animals. The following questions arise from this:

⇨Is it possible to record MFN_T on living animals?

⇨Which relations exist between the MFN_T and performance traits?

⇨Which relations exist between biochemical traits and performance traits?

Methods

Ultrasonic measurements and biopsy samples were taken at 2nd/3rd last rib of M. longissimus dorsi (LD) of 39 sows and barrows of "Schwerfurter Fleischrasse" at a live weight of 90 kg (age about 177 d). Slaughter was carried out at a live weight of 104 kg. Lean content amounted to 49.4 %. The area of LD muscle was determined by ultrasonic measurement at the 2/3 last rib by ultrasonic unit ALOKA SSD 500. For the determination of fibre numbers per unit area (cm^2) as well as further muscle structural and biochemical traits, a shot biopsy sample of LD muscle at 2/3 last rib was taken. One part of each sample was frozen in liquid nitrogen. From these samples 12 µm thick freezer cuts across fibre direction were made and the presence of diaphorase and ATPase was determined histochemically. After that the microstructural traits (percentage and diameter of individual fibre types; number of fibres per cm^2) were determined semiautomaticly with a video image analyzing system. From the other part of the biopsy sample the following biochemical traits were tested for suitability to predict p.m. meat quality:

- Fluid Volume (an indicator for water-holding capacity; measure for liquid leakage from muscle tissue) (Cheah et al., 1991)
- pH_{Biopsy} (pH-value of muscle sample immediately post sampling)
- $pH_{45\ min}$ (pH-value of muscle sample after incubation)
- pH_{Fluid} (pH-value in the supernatant)
- pH-decrease (difference between pH_{Biopsy} and $pH_{45\ min}$)

Results and discussion

Calculated values for the repeatability of ultrasonic measurements amounted to $W \geq 0.95$. For the traits fibre type percentage and MFN_T no significant correlations to slaughter yield and meat quality were found. Positive correlations between fibre diameters and lean content (r = 0.33 to 0.45) as well as the tendency for a negative correlation between MFN_T and lean content of r = -0.30 emphasize the discrepancy between number of fibres and muscle area. There are no correlations between biochemical traits and lean content, however there are low to moderate correlations for single meat quality traits. The results show that the pH_{Biopsy} is not suitable for the prediction of meat quality after slaughter. More exact predictors are possibly the pH-value after 45 mins as well as the pH-decrease. After grouping the animals by MFN_T in three classes (high, medium and low), the tendency to discrepancy between MFN_T and meat yield became visible, too (Table 1). Animals with high number of muscle fibres obtained less lean content and less meat thickness. On the other hand, the meat quality traits were slightly better in animals with high MFN_T. Differences between classes became even more obvious in biochemical traits. With a rising number of fibres, biochemical parameters related to meat quality improved significantly. The contrast between diameter of fibre on one hand and muscle area and MFN_T on the other also becomes clear when the animals are classified according to the obtained lean meat proportion (Table 2). Classes with the highest lean meat proportion (> 52 %, muscle area = 33.5 cm²) had a medium fibre diameter of about 82.6 µm and a MFN_T of only 574 457 fibres. On the other hand, a lean content of only < 48 % and a muscle area of 29.6 cm² was obtained at a MFN_T of 708 791 fibres and medium diameter of 70.8 µm. Despite the general trait difference between MFN_T and lean meat proportion 5 % of the animals in this study obtained high lean meat proportion by an increased MFN_T, thus showing good meat quality. According to Wicke (1989), this percentage even amounts to 10 %. By means of the discriminant function, the separation reliability of the animals by muscle structural and functional traits in the groups of normal and PSE-meat quality was tested (Table 3). Including all muscle structural and functional parameters, 74.6 % of animals were classified correctly. By means of biochemical parameters 74.4 % of animals could be classified correctly. Reliability for the single trait MFN_T was 71.8 %. Other trait combinations analyzed led to the same result.

Conclusions

- Determination of MFN_T in live animals is basically possible.
- Positive correlations between MFN_T and meat quality were determined. These correlations show that hyperplasia is considerably better than hypertrophia for realizing high meat quality.
- The negative correlations between MFN_T and lean content create a need for selection for so-called correlation breakers.
- The prediction of PSE-meat by MFN_T, muscle structure traits and biochemical parameters is possible. These traits may become important during selection against PSE-meat within NN-genotype groups.

Table 1: LSQ-mean values of muscle functions and slaughter traits relative to the total number of muscle fibres

included traits	MFN_T		
	< 570,000 (n=12)	570,000-750,000 (n=18)	> 750,000 (n=9)
Fluid Volume (in ml)	0.478[a]	0.408[b]	0.381[b]
pH-value$_{Biop.}$ muscle	7.1	7.2	7.2
pH-value$_{45\ min}$ muscle	6.3[a]	6.5[b]	6.6[b]
pH-value$_{45\ min}$ Fluid	6.5[a]	6.8[b]	6.8[b]
pH-decrease muscle	-0.8[a]	-0.6[b]	-0.6
lean content	50.5	48.8	48.9
pH-chop$_{120}$	6.2	6.5	6.2
LF- chop $_{24h}$	3.9	3.6	3.3

a, b = significant; $p<0.05$

Table 2: LSQ-mean values of muscle structure traits relative to lean meat content

included traits		lean meat content		
		< 48 % (n=12)	48-52 % (n=18)	> 52 % (n=9)
fibre types percentage	red	11.0	11.8	11.4
	intermediate	15.7	13.2	15.6
	white	67.3	68.9	67.7
fibre diameter (µm)	red	59.0	61.4	65.0
	intermediate	55.7	61.3	63.4
	white	77.8[a]	82.1[a]	92.3[b]
	total	70.8[a]	75.5	82.6[b]
MFN_T		708791	670732	574457
muscle area (cm^2)		29.6[a]	31.5	33.5[b]

a, b, c = significant; $p< 0.05$

Table 3: Reliability of discriminant function derived from muscle structure and functional traits in normal and PSE-meat quality

included traits		discriminant functions							
		1	2	3	4	5	6	7	8
MFN_T		X	X					X	
fibre types percentage	red	X	X						
	intermediate	X	X						
	white	X	X		X				
fibre diameter (µm)	red	X	X				X		
	intermediate	X	X						
	white	X	X			X			
	total	X	X						
biochemical traits	Fluid Volume in ml	X		X					
	pH-value$_{Biop.}$ muscle	X		X	X	X	X		
	pH-value$_{45\ min}$ muscle	X		X					X
	pH-value$_{45\ min}$ Fluid	X		X					
classification correct (%)		74.6	71.8	74.4	71.8	71.8	71.8	71.8	71.8

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