MUSCLE FIBRE CHARACTERISTICS IN GROWING BEEF CATTLE OF DIFFERENT BREEDS RELATION TO MEAT QUALITY

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Background
The amount of lean meat is mainly determined by muscle fibre number and muscle fibre size. The postnatal growth of muscle is essentia hypertrophy of the existing muscle fibres. It is well known that muscle fibre size, the type frequencies and the total muscle fibre numb fect the meat quality in pigs.

Objective
The objective of the study was to examine the known correlation between muscle structure traits and meat quality in cattle.

Material and Methods
Sixty bulls (White-Blue Belgian, German Angus, Galloway and Black Pied breeds, 15 each) were kept under the same conditions until days of life. Muscle samples of *semitendinosus muscle* were taken by the shot biopsy at 140, 180, 240, 300, 400, 500, 600, and 700 days of life. In addition 5-10 bulls of each breed were slaughtered at 0, 2, 4, 6, 12, 18, and 24 months of age and muscle samples were taken 24 h p.m. Samples both from living animals and carcasses were immediately frozen in liquid nitrogen and later cut with a cryostat microtome (10 µm). For fibre typing, sections were stained for myosin adenosine triphosphatase activity after alkaline preincubation (Fig. 1). About 500 muscle fibres in randomly selected bundles of each sample were measured and identified by image analysis. The total muscle fibre number was calculated from muscle cross section area and muscle fibre number per cm². The meat quality parameters Warner-Bratzler (WB) shear force value, cooking loss, pH-value, meat colour, and intramuscular fat content of *semitendinosus muscle* were determined. The data were analysed by the General Linear Model procedure of Statistical Analysis System (SAS© 6.11). LSMEANS in tables with similar letters are not significantly different, capital letters refer to differences between the age groups, small letters between the breeds.

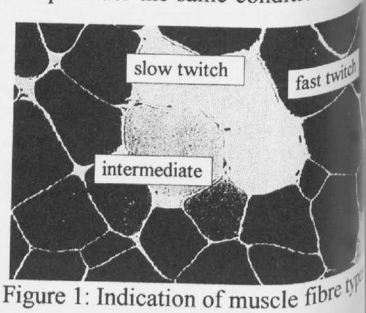

Figure 1: Indication of muscle fibre typ

Table 1: Muscle fibre diameter during growth [µm]

age [months]	White-Blue Belgian	German Angus	Galloway	Black Pied
0	25 ^{Aa}	28 ^{Aa}	30 ^{Aa}	26 ^{Aa}
2	34 ^{Ba}	41 ^{Bb}	40 ^{Bab}	40 ^{Bab}
4	43 ^{Ca}	54 ^{Cb}	47 ^{Cab}	47 ^{Cab}
6	50 ^{Dab}	53 ^{Ca}	46 ^{Cb}	49 ^{Cab}
12	66 ^{Ea}	68 ^{Da}	67 ^{Da}	63 ^{Da}
18	80 ^{Fa}	80 ^{Ea}	73 ^{Eb}	66 ^{Dc}
24	80 ^{Fac}	91 ^{Fb}	84 ^{Fa}	78 ^{Ec}

Table 2: Total muscle fibre number during growth [x 10^{6}]

age [months]	White-Blue Belgian	German Angus	Galloway	Black Pied
0	3.9 ^{Aa}	2.1 ^{Ab}	1.3 ^{Ab}	2.0 ^{ABb}
2	3.5 ^{ABa}	1.9 ^{Ab}	1.4 ^{ABb}	1.7 ^{Ab}
4	3.6 ^{ABa}	1.6 ^{Ab}	1.5 ^{ABb}	1.6 ^{ABb}
6	3.1 ^{Ba}	1.7 ^{Ab}	1.9 ^{Bb}	1.8 ^{ABb}
12	3.1 ^{Ba}	1.8 ^{Ab}	1.7 ^{ABb}	1.8 ^{ABb}
18	3.4 ^{ABa}	1.8 ^{Ab}	1.7 ^{ABb}	2.1 ^{Bb}
24	3.4 ^{Ba}	1.7 ^{Ab}	1.7 ^{ABb}	1.8 ^{ABb}

Results and Discussion
Although the meatiness is different between the four breeds, the **muscle fibre diameter** was only slightly different in all age groups of diff ent animals (Tab. 1 serial slaughter trial) and during the lifetime of the same animal (Fig. 5a biopsy trial). Between the beef cattle bre German Angus and the dairy cattle breed Black Pied was a difference of about 13 µm at the age of 24 months. This difference is associa with differences in meatiness, because the **total muscle fibre number** (Tab. 2) is at the same level. The muscle fibre diameters of the Wh Blue Belgian and Galloway were between them. That means that the muscular hypertrophy in double muscled cattle is not the result of mu cle fibre hypertrophy. The high percentage of muscle in White-Blue Belgian double muscled cattle is caused by the doubling of total mus fibre number in this breed. The total muscle fibre number is fixed at birth.

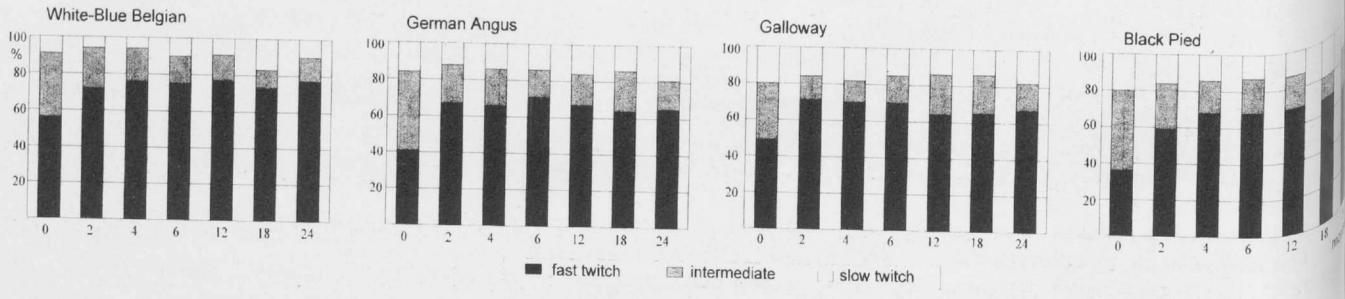

Figure 2: Changes of muscle fibre type frequencies during growth

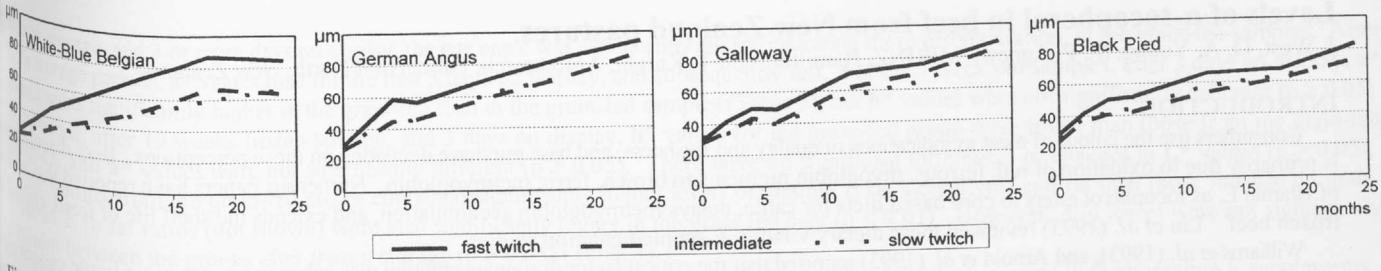

Figure 3: Changes of diameters of muscle fibre types during growth

The **muscle fibre type frequencies** changed in all investigated breeds from birth up to 2 months of age (Fig. 2). The percentage of fast twitch fibres increased at the expense of the intermediate fibres. In White-Blue Belgian the percentage of fast twitch fibres is significant higher already at birth. The slow twitch and intermediate fibres of White-Blue Belgian grew at a lower level in comparison to the other breeds (Fig. 3). Therefore, the slow twitch fibre cross section area in the muscle is significant lower in the White-Blue Belgians.

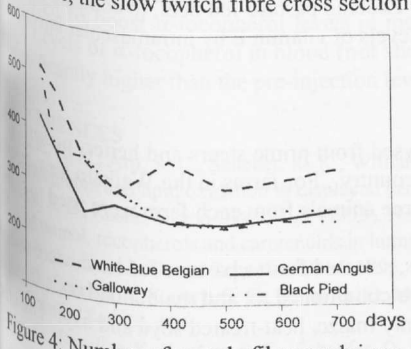

Figure 4: Number of muscle fibre nuclei per mm² muscle fibre area (biopsy)

The number of **muscle fibre nuclei** per muscle fibre area, including nuclei of satellite cells, decreased until 300 days of life in all breeds and then stood constant until 700 days (Fig. 4). The White-Blue Belgian had the highest number of nuclei per fibre area. That means that the White-Blue Belgian has a higher muscle growth potential.

The **meat quality** traits WB shear force value, cooking loss, pH-value (data not shown) and meat colour (Tab. 3) were not different between the German Angus, Galloway and Black Pied cattle. Only the White-Blue Belgian had a significant paler and more exudative meat. This agrees with results of Uytterhaegen et al. (1994).

The comparison between the animal species cattle and pig (Fig. 5) shows dramatically differences in the growth of the muscle fibres. The one-sided selection for high meatiness led to a stronger hypertrophy of the muscle fibres and a higher percentage of fast twitch fibres in pigs. Clear differences existed between different boar progeny groups. Extremely large muscle fibres and an especially high percentage of fast twitch fibres are connected with inferior meat quality (PSE) (Wegner and Ender 1990, Fiedler et al. 1993, Wicke et al. 1996). This could not be confirmed in cattle. Hence, no large differences in the muscle fibre diameter were found despite of clear differences in the muscle hypertrophy of the examined cattle. The enormous muscle mass of the double muscled cattle is not developed by hypertrophy but by hyperplasia already before birth. With these animals, already at birth exist a high percentage of fast twitch fibres in the muscle, and this leads to brighter and more exudative meat.

Table 3: Meat colour (brightness, L*)

age [months]	White-Blue Belgian	German Angus	Galloway	Black Pied
0	46.3 $^{AC\,a}$	49.6 $^{A\,ab}$	48.5 $^{A\,ab}$	50.1 $^{A\,b}$
2	49.7 $^{B\,a}$	44.3 $^{B\,b}$	46.4 $^{AB\,ab}$	44.4 $^{B\,b}$
4	48.6 $^{AB\,a}$	40.3 $^{CD\,b}$	44.3 $^{B\,c}$	42.8 $^{B\,bc}$
6	45.8 $^{C\,a}$	44.2 $^{B\,ab}$	43.3 $^{BC\,b}$	44.6 $^{B\,ab}$
12	43.1 $^{D\,a}$	43.1 $^{BC\,a}$	41.4 $^{C\,a}$	43.3 $^{B\,a}$
18	44.0 $^{CD\,a}$	38.9 $^{DE\,b}$	38.6 $^{D\,b}$	40.0 $^{C\,b}$
24	40.8 $^{E\,a}$	37.2 $^{E\,b}$	37.8 $^{D\,b}$	36.9 $^{D\,b}$

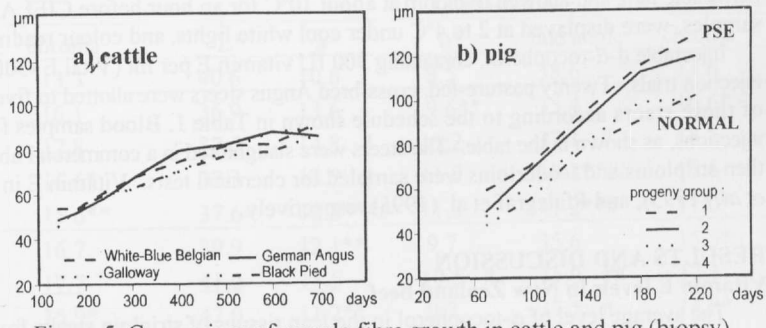

Figure 5: Comparison of muscle fibre growth in cattle and pig (biopsy)

Conclusion

With the exception of the double muscled cattle, the muscle fibre characteristics of the cattle are only little changed by breeding in contrast to pig, and there are hardly indications for effects on the beef meat quality. Only with cattle of the breed White-Blue Belgian (double muscled) meat quality problems arise despite of high total muscle fibre number because of changes in the fibre type frequencies. The improvement of the meat quality with constant high meatiness by breeding should be directed to a high total number and a higher percentage of slow twitch fibres. Since both characteristics are fixed in the myogenesis, a prediction is possible shortly after the birth.

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