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HISTOCHEMICAL PROPERTIES OF FIBRE TYPES IN MUSCLES OF WILD AND DOMESTIC PIGS AND THE EFFECT OF GROWTH RATE ON MUSCLE FIBRE PROPERTIES

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Abstract

This study reports the results of a comparison of the histochemical properties of various types of porcine muscles in wild and domestic pigs. In domestic pigs, the influence of growth rates on these properties were studied in five muscles: *longissimus dorsi* (LD), *semimembranosus* (SM), *gluteus superficialis* (GS), *infra spinam* (IS) and *masseter* (MAS). The growth rate was expressed as (i) live weight (LW) at 165 ± 2 d and (ii) daily LW gain from day 88 to day 165 (DG) on the experimental diet.

LD, SM, GS and IS of wild pigs were found to contain a higher area percentage of oxidative type IIA fibres (type IIA%_{area}) and a lower percentage area of glycolytic type IIB fibres (type IIB%_{area}) than the same muscles of domestic pigs. The capillary density in the light muscles (LD, SM, GS) of wild pigs was twice that of domestic pigs, indicating higher oxidative capacity. In domestic pigs the cross sectional area of type IIB fibres (CSA_{IIB}) was markedly larger than the cross sectional area of type I (CSA_I) and IIA (CSA_{IIA}) fibres. The average fibre cross sectional area (CSA_{fibre}) was about the same in the muscles of wild and domestic pigs except in LD and SM, where the average fibre cross sectional area was approximately 25% smaller in wild pigs than in domestic pigs. This difference was caused by

the large cross sectional area of type IIB fibres in the light muscles of domestic pigs.

In the light muscles of domestic pigs, the cross sectional area of type IIA fibres increased most with increasing growth rate. Growth rate influences muscle fibre properties only in light muscles, not in dark muscles.

Keywords: domestic pig; wild pig; muscle fibre types; growth rate

1. Introduction

Dark, aerobic muscles contain mainly oxidative type I and oxidative/glycolytic type IIA fibres with high myoglobin content. Light muscles, on the other hand, contain glycolytic type IIB fibres with a low myoglobin content (Morita, Cassens, Briskey, Kauffman & Kastenschmidt (1970). In light muscles of domestic pigs, type I and type IIA fibres are usually smaller than type IIB fibres. There are more capillaries around the type I and IIA fibres than around the type IIB fibres (Kalström, 1995).

Domestic pigs are selected on the basis of their ability to grow rapidly. Intensive selection for growth rate and higher proportions of lean may have caused a change in fibre type composition in the direction of a higher proportion of larger type IIB fibres. In addition, the fibre diameter in domestic pigs has increased compared to that of less developed breeds at the same age. Many of the muscles of domestic pigs contain more type IIB fibres and less type IIA fibres than the muscles of wild pigs (Rahelic & Puac, 1981; Szentkuti, Niemeyer & Schlegel, 1981; Bader, 1983; Essen-Gustavsson & Lindholm, 1984; Weiler, Appell, Kermser, Hofaker & Claus, 1995).

The rate of muscle fibre differentiation varies in different muscles. In young animals, muscle fibres begin in an undifferentiated, oxidative state (Cassens and Cooper 1971, Ashmore and Doerr 1972). There are two basic muscle fibre types, called α (type II) and β (type I), based on their myosin ATPase activity (Ashmore and Doerr 1972). Initially, α fibres are oxidative, but have the capacity to be transformed from an aerobic state to an anaerobic state of metabolism. Beta fibres remain aerobic throughout their lifespan. This transformation occurs primarily due to changes in energy-producing enzymes and is accompanied by a rapid increase in fibre size (Swatland 1973). Differentiation into different muscle fibre types proceeds at different rates, and some enzymes show differentiation before others. Muscle fibre differentiation is neurally regulated, so that the differentiation starts after the development of the nerve junctions (Beermann, Cassens & Hausman, 1978, Swatland and Cassens 1973, Swatland 1985). Cassens, Cooper and Briskey (1969) and Ashmore, Tompkins and Doerr (1972) reported that the degree to which α_R (IIA) fibres are transformed into α_W (IIB) fibres in porcine muscles has an effect on muscle size.

According to Stickland, Widdowson and Goldspink (1975) the number of muscle fibres is determined genetically before birth, and thereafter only the length and the cross sectional area of the muscle fibres increase. Fibre formation is known to be complete between 70th and 90th d after conception (Swatland, 1973, Wigmore & Stickland, 1983). The development of type II muscle fibres is estimated to begin approximately 55 days after conception in pigs (Swatland 1973). At birth, the cross sectional area of muscle fibres in *gastrocnemius* is the largest, while that in *longissimus dorsi* is the smallest. After birth, the cross sectional area of muscle fibres in *longissimus dorsi* increases most and that in *gastrocnemius* least (Lawrie, 1985).

The objectives in this study were (i) to compare fibre type histochemical properties in muscles of wild and domestic pigs and (ii) to study the effect of the growth rate on the histochemical properties of muscle fibre in three light muscles (*longissimus dorsi* (LD), *semimembranosus* (SM), *gluteus superficialis* (GS)) and two dark muscles (*infra spinam* (IS) and *masseter* (MAS)) in domestic pigs. Growth rate in this study was expressed as (i) live weight (LW) at 165 ± 2 d and (ii) daily LW gain from day 88 to day 165 (DG) of the experimental diet.

2. Materials

Muscle samples were collected from 20 pairs of pigs. The pairs consisted of full sib pigs (brothers and sisters). To achieve a variation in the growth rate, one pig of each pair received a barley-soybean meal-based diet that contained 6.0 g ileal digestible lysine per feed unit, and the other pig received food that contained 9.5 g ileal digestible lysine per feed unit. The average live weight of the pigs was 23.9 ± 2.86 kg and the average age 71 ± 7.3 days when they started to receive the experimental diet.

The pigs were raised at Agricultural Research Centre of Finland (MTT) in Hyvinkää and slaughtered at the age of 165 ± 2 d at the experimental abattoir of University of Helsinki/Department of Food Technology/Meat Technology. The pigs were allowed to rest for two hours after transport and then electrically stunned. The average live weight (LW) of the domestic pigs (N=40) was 105.1 ± 8.8 kg (range from 86.0 kg to 118.5 kg) and the average slaughter weight (N=40) was 81.0 ± 7.6 kg. In this

study, the experimental diet period used in calculations was from 88 days of age to 165 days (DG) even though the experimental diet was actually started when the pigs reached a certain weight. This period was chosen because this was the longest time period when every pig received the experimental diet. The average length of DG was 77.3 ± 1.2 days and the average corresponding daily gain was 898.1 ± 79.0 g

In addition, samples of the same muscles were taken from six wild pigs, aged one to three years. It was not possible to weigh them because they were being raised in an enclosed area in the forest. The carcass weights of the wild pigs were 72.7, 79.8, 29.2, 46.6, 32.4 and 43.7 kg, while the percentages of the weight of the head compared to the total carcass weight were 10.6, 8.5, 13.4, 9.7, 16.4 and 16.7%, respectively.

One day after slaughter, the carcasses were totally dissected into lean meat, fat, skin and bone. Lean meat content in the carcasses of domestic pigs was on average 48.8 kg and in the carcasses of wild pigs on average 25.9 kg.

Shortly after slaughter (15 min – 40 min), samples were taken from three light muscles, viz. *longissimus dorsi* (LD), *gluteus superficialis* (GS) and *semimembranosus* (SM), and from two dark muscles, viz. *infra spinam* (IS) and *masseter* (MAS). These samples were frozen in liquid nitrogen and stored at -80°C until analysis.

3. Methods

In order to classify the muscle fibres into type I, type IIA and type IIB groups, cross sections (14 μm) were cut at -24°C in a cryostat (Reichert-Jung 2800 E, Germany) and stained using the myosin ATPase method (Brooke and Kaiser 1970) with an acid preincubation solution (pH 4.6). α -amylase-PAS staining facilitated the counting of the number of capillaries per mm^2 (Andersen 1975).

Stained sections were examined with an image analysis system using a computer program (KS300, Carl Zeiss Vision GmbH, Germany). The following parameters were computed: area percentage of different fibre types (%) (type I%_{area}, type IIA%_{area}, type IIB%_{area}), cross-sectional area of each fibre type (μm^2) (CSA_I ; CSA_IIA ; CSA_IIB) using sections stained with myosin ATPase method, and number of capillaries per mm^2 . A magnification of 150x was used. The average muscle fibre size (CSA_fibre) was calculated by dividing the whole muscle area by the number of corresponding fibres. The fibres were always counted in an area of about 1 mm^2 . Two different pieces of each muscle sample were stained, and more than 200 muscle fibres/sample were analysed.

3.1 Statistical analyses

The differences in histochemical properties between the domestic and wild pigs were studied using the analysis of covariance including the carcass weight as covariate. The relationship between growth rate and histochemical properties was described using correlation coefficients. Partial correlation coefficients were used in order to adjust for the effect of feeding group. The data were analysed statistically using the SAS program (SAS Institute Inc., 1990)

4. Results

4.1 *Wild pigs vs. domestic pigs*

The area percentage of type IIB fibres was smaller and that of type IIA fibres larger ($p<0.05$) in the light muscles of wild pigs (LD, SM and GS) than in the same muscles of domestic pigs (Table 1). As in the light muscles of domestic pigs, more than a half of the muscle area in wild pigs consisted of type IIB fibres.

In wild pigs, the difference in fibre cross sectional area between the different fibre types was smaller than in domestic pigs, where the cross sectional area of type IIB fibres was markedly larger in LD, SM and GS than the cross sectional area of type I and IIA fibres (Table 1). In this study, the capillary density in LD, SM and GS was twice as high in wild pigs as in domestic pigs ($p<0.05$) (Table 1).

The area percentage of IIA fibres was larger and that of type IIB fibres was smaller in IS of wild pigs than in IS of domestic pigs ($p<0.05$). In IS, the difference between wild and domestic pigs in area percentage of type IIA fibres and in type IIB fibres was about the same as was found in LD, SM or GS (Table 1). The area percentage of type I fibres was in MAS, however, much larger in wild pigs than in domestic pigs ($p<0.05$). In IS and MAS of wild pigs, the capillary density was also a little higher than in the same muscles of domestic pigs, but the difference in the dark muscles was not as great as that found in LD, SM or GS (Table 1).

Some 'giant fibres' were also observed in this study in some domestic pigs, exclusively in the light muscles. Giant fibres stained similarly to type IIA fibres, the shape was round and the cross sectional area large. Solomon and Eastridge (1987) found giant fibres also in wild boars, but in this study no giant fibres were found in muscles of wild pigs.

4.2. Muscle histochemical properties in relation to growth rate in domestic pigs

In LD, GS, and SM muscles, the average fibre cross sectional areas (total area/number of muscle fibres) were 5.23 , 5.33 and $5.65 \times 10^3 \mu\text{m}^2$, respectively. The average fibre cross sectional area in IS was also quite large, on average $5.14 \times 10^3 \mu\text{m}^2$, but small in MAS, on average $2.75 \times 10^3 \mu\text{m}^2$. The highest capillary density was found in MAS, on average 538 capillaries per mm^2 , and the lowest in LD, on average 162 capillaries per mm^2 (Table 1). The largest area of MAS consisted of small type IIA and type I fibres that were surrounded by more capillaries than type IIB fibres. A notable difference between dark IS and dark MAS was that in IS the area percentage of type I ($\text{I}\%_{\text{area}}$) and type IIB ($\text{IIB}\%_{\text{area}}$) fibres was higher and that of type IIA ($\text{IIA}\%_{\text{area}}$) lower than in MAS.

In Table 2 are shown the effect of growth rate on the histochemical properties of muscle fibres in the studied muscles. In LD, a positive correlation was found between LW and area percentage of type I fibres ($r=0.361$, $p<0.05$) and, a negative correlation between LW and area percentage of type IIB fibres ($r=-0.345$, $p<0.05$). This was not found in the other studied light muscles, neither in MAS nor in IS.

In LD, the cross sectional area of all fibre types increased when growth rate increased (Table 2) but

only the correlation between DG and CSA_I was significant ($r=0.327$, $p<0.05$). In SM, the cross sectional area of type IIA fibres increased most when growth rate increased. The correlation coefficient between LW and CSA_{IIA} was $r=0.424$ ($p<0.05$) and between DG and CSA_{IIA} $r=0.439$ ($p<0.05$) (Table 2). Although, the cross sectional area of type IIA fibres increased most in LD, SM and GS, the area percentage of type IIA fibres ($type\ IIA\ \%_{area}$) did not increase in these muscles when growth rate increased.

When the growth rate increased the capillary density decreased in light muscles but the correlation between LW and capillary density and between DG and capillary density were not significant ($p>0.05$) (Table 2). It has been shown, especially for light muscles, that when the cross sectional area of fibres in a muscle increases, the capillary density decreases. Growth rate also had no influence on the histochemical properties in the fibres of IS and MAS (Table 2).

5. Discussion

Wild boars have a considerably slower growth rate than domestic pigs. Müller, Moser, Bartenschlager and Geldermann (2000) reported that Pietrain pigs weighed 117.1 kg, Meishan pigs 82.5 kg and wild pigs 48.4 kg at age 210 days. In this study, 165d old domestic pigs weighed on average 105.1 kg. It was not possible to weigh the live wild pigs but they weighed much less than the domestic pigs despite being two to six times older.

We decided to include some wild pigs in this study to obtain comparable histochemical, biochemical and anatomical data that would more or less indicate the original relationship of these traits in pigs in nature. Our findings here are in agreement with those of Rahelic & Puac, 1981; Szentkuti, Niemeyer & Schlegel, 1981; Bader, 1983; Essen-Gustavsson & Lindholm, 1984; Weiler, Appell, Kermser, Hofaker & Claus, 1995 and Fiedler, Rehfeldt, Albrecht & Henning, 1998, who have shown that most muscles of wild pigs contained a higher percentage of oxidative type IIA fibres and a lower percentage of glycolytic type IIB fibres than the same muscles of domestic pigs. The capillary density was higher in the muscles of wild pigs (Table 1), as Karlström (1995) also showed in her study of muscles of wild boars and domestic pigs having the same body weight. Because the age, the size and the nutritional status of the wild pigs could not be controlled for in this study, the results for wild pigs are arbitrary.

Bader (1983) measured the cross sectional area of muscle fibre in *longissimus dorsi* of 200d old wild pigs and domestic pigs. In domestic pigs (live weight of 121.5 kg), the cross sectional area of type I fibres was $5.0 \times 10^3 \mu\text{m}^2$ and that of type II fibres $7.3 \times 10^3 \mu\text{m}^2$, and in wild pigs (live weight of 30 kg) 2.0 and 2.5×10^3 , respectively. However, Karlström (1995) has shown that the muscles of wild boars have larger fibres than the muscles of domestic pigs with the same body weight. In this study, the cross sectional area of type IIB fibres in the light muscles of domestic pigs was markedly larger than that of wild pigs although the wild pigs were two to six times older than the domestic pigs. The average cross sectional area of muscle fibres of domestic pigs and wild pigs did not differ as much, because there were more type I and type IIA fibres with larger cross sectional area in wild pigs than in domestic pigs. The average lean meat content in the carcasses of domestic pigs was 48.8 kg, but only 25.9 kg in the carcasses of wild pigs. Because the average cross sectional area of muscle fibres in domestic and wild pigs was about the same, it can be concluded that the number of muscle fibres must be higher and/or the muscle fibres must be longer in the muscles of domestic pigs than in those of wild pigs.

Fang, Nishimura and Takahashi (1999) found that the muscle fibre diameter of porcine *semitendinosus* increased 170% from birth to one month, 122% from one month to three months, 46% from three to six months and only 17% from six to 55 months of age. Chrystall, Zobriski and Bailey (1969) found similar results for porcine *longissimus dorsi*. Muscle fibre diameter increased 100% from birth to 25 days, whereas from 100 to 125 days of age, muscle fibre diameter increased only 10%. The rate of muscle fibre growth after 150 days was very slow. Oksbjerg, Henckel and Rolph (1994) have shown that the rate of increase in muscle fibre area was almost constant from 25 to 90 kg live weight, and that the rate of growth was two-fold in IIB fibres compared to that of type I fibres. In addition, other researchers have found that the sizes of various fibre types in *longissimus dorsi* increased at different rates, with the diameter of type II fibres increasing faster than that of type I (Cooper, Cassens, Kastenschmidt & Briskey, 1970; Davies, 1972; Rede, Pribisch & Rahelic, 1986; Wegner & Ender 1990; Fiedler, Wegner & Feige, 1991).

Miller, Garwood and Judge (1975) and Henckel, Oksbjerg, Erlandsen, Barton-Gade and Bejerholm (1997) found that faster-growing pigs appeared to have more numerous, but smaller fibres in *longissimus dorsi* than did slower-growing pigs. Dwyer, Fletcher and Stickland (1993) found the same in porcine *semitendinosus*, i.e. fast-growing strains of pigs tend to have more numerous muscle fibres than slow-growing strains. Staun (1963) found just the opposite. He reported that rapid-growing and muscular pigs have large muscle fibres in *longissimus dorsi*. The number of muscle fibres was not determined in the present study, but only the average cross sectional area of muscle fibres. The growth rate did not have any effect on average fibre size ($p>0.05$). The growth rate was expressed as live weight or daily live weight gain from age 88d to age 165d. There are at least two reasons why no effect was found: both LW and DG varied very little and the pigs were not selected on the basis of

differences in genetic growth rate. The results might have been different if the age or live weight period had been other than that used. The effect of the growth rate on average fibre size was more marked in the light muscles than in the dark muscles.

When the sizes of different fibre types in the light muscles of domestic pigs and of wild pigs were compared, CSA_{IIB} was markedly larger than CSA_I and CSA_{IIA} in the domestic pigs, but in the wild pigs the sizes of all fibre types were closer to each other. Early in life the difference in cross sectional area between the fibre types is marginal, but when the pigs reach slaughter weight, the cross sectional area of type IIB fibres is largest in the light muscles. According to Bader (1983) the relative growth of type II fibres is fastest at the age of one to two months. It may be assumed that type IIB fibres grow more/faster than type I and type IIA fibres in the earlier age period, but this did not come out in this study, where the studied weight/age period was a later phase of life. It is not clear why type IIB fibres in domestic pigs are two times larger than type I or type IIA fibres, in contrast to the findings for wild pigs, however selection based on enhanced lean content may be one factor favouring larger type IIB fibres. Is it possible to increase the cross sectional area of type IIB fibres even more? At the same time, the cross sectional area of type IIB fibres in the domestic pigs is large and the capillary density is low, so it can be assumed that the muscle does not function very well. The capillaries are located in the endomysium. Consequently, when the fibre cross sectional area increases, the number of capillaries per area decreases. Larger fibres also tend to have a lower numbers of mitochondria per unit area, and are thus less oxidative.

The light muscles utilise glycogen to a greater extent than the dark muscles, resulting in lactate accumulation in the muscles. The large fibre size with low capillary density makes it more difficult to extract lactate from muscle fibre. Therefore, carcasses should be chosen with smaller type IIB fibres in

the light muscles, because small fibre cross sectional area facilitates lactate diffusion from the cell and thus contributes to animal welfare.

Muscles having a large number of fibres with a small cross sectional area have more growth potential than muscles with a small number of fibres and a large cross sectional area, without any decrease of the oxidativity of the muscles (Ashmore & Vigneron 1988). Petersen et al. (1999) compared the muscle properties of two groups of Danish Landrace pigs known to differ in their growth rates after 20 years of genetic selection for growth performance and carcass traits in one group. The selected pigs reached slaughter weight 25 days earlier than the non-selected pigs. Histochemical analyses showed that the percentage of the glycolytic type IIB fibres was significantly higher and the percentage of oxidative type I fibres significantly lower in selected pigs, but surprisingly the selection did not result in a larger mean fibre area. The smaller fibre area also resulted in higher capillary density in the selected pigs (166 versus 154). This indicated that the selected pigs have a larger number of muscle fibres.

The goal in pig breeding remains to increase muscle mass, and large light muscles are economically very important. We have shown that when growth rate increases, the cross sectional area of type IIA fibres increases most in the light muscles. As their number is very low, they cannot have any substantial effect on muscle size. Giant fibres found in this study were classified as type IIA fibres. Their cross sectional area was large, but their number was very low and they were found only in some pigs. Consequently, the incidence of giant fibres cannot explain the significant positive correlation between the growth rate and CSA_{IIA} .

During the growth of a pig more changes were found in histochemical properties of light muscles than of dark muscles. The growth rate of dark muscles did not affect any histochemical property ($p>0.05$) (Table 2). Accordingly, more attention in breeding should be paid to the muscle fibre properties in

light muscles than in dark ones, especially because light muscles are economically more important.

6. Conclusions

Wild pigs have more oxidative type IIA fibres than domestic pigs, especially in the light muscles. The capillary density is also higher in the muscles of wild pigs, indicating higher oxidative capacity.

In domestic pigs the cross sectional area of type IIB fibres is markedly larger than the cross sectional area of type I and IIA fibres. In wild pigs the cross sectional area of all fibre types is about the same. The average fibre cross sectional area is about the same in the muscles of wild and domestic pigs, except in LD and SM, where the average fibre cross sectional area in wild pigs is ca. 25% smaller than in domestic pigs. This difference is caused by the large cross sectional area of type IIB fibres in the light muscles of domestic pigs.

In the light SM and GS of domestic pigs the cross sectional area of type IIA fibres and in the light LD, the cross sectional area of both type I fibres and type IIA fibres increases most with increasing growth rate. Growth rate influences muscle fibre properties only in light muscles, not in dark muscles.

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Table 1. Area percentage of different fibre types ($I\%_{\text{area}}$, $IIA\%_{\text{area}}$, $IIB\%_{\text{area}}$)(%), cross sectional area of different fibre types (CSA_I , CSA_{IIA} , CSA_{IIB}), average fibre cross sectional area (CSA_{fibre}) and capillary density of muscles of domestic and wild pigs. Means and standard errors (s.e).

	Domestic pigs (N=40)		Wild pigs (N=6)		P
	Mean	s.e	Mean	s.e	
<i>M. longissimus dorsi</i>					
$I\%_{\text{area}}$	6,5	0,3	13,0	2,0	*
$IIA\%_{\text{area}}$	3,2	0,3	17,3	2,0	*
$IIB\%_{\text{area}}$	90,3	0,4	69,7	3,0	*
$CSA_I, 10^3 \mu\text{m}^2$	2,95	0,09	3,40	0,43	NS
$CSA_{IIA}, 10^3 \mu\text{m}^2$	2,75	0,13	2,90	0,36	NS
$CSA_{IIB}, 10^3 \mu\text{m}^2$	5,79	0,19	3,74	0,50	*
$CSA_{\text{fibre}}, 10^3 \mu\text{m}^2$	5,25	0,16	3,49	0,42	*
Capillaries/mm ²	162	5	345	27	*
<i>M. semimembranosus</i>					
$I\%_{\text{area}}$	6,6	0,3	16,6	1,8	*
$IIA\%_{\text{area}}$	3,6	0,3	16,1	2,2	*
$IIB\%_{\text{area}}$	89,8	0,3	67,3	2,8	*
$CSA_I, 10^3 \mu\text{m}^2$	3,05	0,09	3,89	0,65	*
$CSA_{IIA}, 10^3 \mu\text{m}^2$	3,48	0,12	3,23	0,48	NS
$CSA_{IIB}, 10^3 \mu\text{m}^2$	6,21	0,15	3,76	0,43	*
$CSA_{\text{fibre}}, 10^3 \mu\text{m}^2$	5,65	0,13	3,64	0,44	*
Capillaries/mm ²	216	6	446	28	*
<i>M. gluteus superficialis</i>					
$I\%_{\text{area}}$	6,8	0,2	17,9	1,6	*
$IIA\%_{\text{area}}$	4,0	0,3	16,4	2,6	*
$IIB\%_{\text{area}}$	89,3	0,3	65,8	1,5	*
$CSA_I, 10^3 \mu\text{m}^2$	2,88	0,10	4,07	0,66	*
$CSA_{IIA}, 10^3 \mu\text{m}^2$	3,42	0,16	3,43	0,52	NS
$CSA_{IIB}, 10^3 \mu\text{m}^2$	5,94	0,19	4,76	0,81	*
$CSA_{\text{fibre}}, 10^3 \mu\text{m}^2$	5,33	0,15	4,31	0,66	*
Capillaries/mm ²	191	5	409	25	*
<i>M. infra spinam</i>					
$I\%_{\text{area}}$	53,0	2,4	55,3	6,5	NS
$IIA\%_{\text{area}}$	19,7	1,0	33,5	3,4	*
$IIB\%_{\text{area}}$	27,3	2,7	11,3	4,3	*
$CSA_I, 10^3 \mu\text{m}^2$	4,78	0,14	4,45	0,47	NS
$CSA_{IIA}, 10^3 \mu\text{m}^2$	5,39	0,20	4,23	0,49	*
$CSA_{IIB}, 10^3 \mu\text{m}^2$	5,78	0,19	4,74	0,89	NS
$CSA_{\text{fibre}}, 10^3 \mu\text{m}^2$	5,14	0,14	4,46	0,51	*
Capillaries/mm ²	369	7	470	21	*
<i>M. masseter</i>					
$I\%_{\text{area}}$	22,5	1,0	68,0	8,3	*
$IIA\%_{\text{area}}$	70,8	1,4	28,7	9,3	*
$IIB\%_{\text{area}}$	6,7	1,4	3,3	1,2	NS
$CSA_I, 10^3 \mu\text{m}^2$	2,70	0,07	3,24	0,30	*
$CSA_{IIA}, 10^3 \mu\text{m}^2$	2,85	0,07	2,7	0,24	NS
$CSA_{IIB}, 10^3 \mu\text{m}^2$	2,45	0,07	2,41	0,29	NS
$CSA_{\text{fibre}}, 10^3 \mu\text{m}^2$	2,75	0,07	3,05	0,28	NS
Capillaries/mm ²	538	12	651	32	*

* p<0.05; NS = non significant

Table 2. Correlation coefficients in *M. longissimus dorsi*, *M. semimembranosus* and *M. gluteus superficialis* and *M. masseter* and *M. infra spinam* between the histochemical properties and live weight (LW) as well as the histochemical properties and daily live weight gain (DG).

	LW (kg)	P	DG (g/d)	P
<i>M. longissimus dorsi</i>				
I% _{area}	0,361	*	0,205	NS
IIA% _{area}	0,030	NS	0,102	NS
IIB% _{area}	-0,345	*	-0,268	NS
CSA _I , 1000 μm^2	0,272	NS	0,327	*
CSA _{IIA} , 1000 μm^2	0,287	NS	0,303	NS
CSA _{IIB} , 1000 μm^2	0,193	NS	0,148	NS
Capillaries/mm ²	-0,248	NS	-0,120	NS
<i>M. semimembranosus</i>				
I% _{area}	0,138	NS	0,154	NS
IIA% _{area}	-0,037	NS	0,134	NS
IIB% _{area}	-0,069	NS	-0,214	NS
CSA _I , 1000 μm^2	0,069	NS	0,173	NS
CSA _{IIA} , 1000 μm^2	0,424	*	0,439	*
CSA _{IIB} , 1000 μm^2	0,238	NS	0,184	NS
Capillaries/mm ²	-0,199	NS	-0,122	NS
<i>M. gluteus superficialis</i>				
I% _{area}	-0,043	NS	-0,076	NS
IIA% _{area}	0,065	NS	0,012	NS
IIB% _{area}	-0,027	NS	-0,057	NS
CSA _I , 1000 μm^2	0,133	NS	0,204	NS
CSA _{IIA} , 1000 μm^2	0,234	NS	0,314	NS
CSA _{IIB} , 1000 μm^2	-0,067	NS	-0,037	NS
Capillaries/mm ²	-0,207	NS	-0,141	NS
<i>M. masseter</i>				
I% _{area}	-0,097	NS	0,051	NS
IIA% _{area}	0,214	NS	0,177	NS
IIB% _{area}	-0,145	NS	-0,210	NS
CSA _I , 1000 μm^2	0,058	NS	0,231	NS
CSA _{IIA} , 1000 μm^2	-0,177	NS	0,071	NS
CSA _{IIB} , 1000 μm^2	-0,006	NS	0,177	NS
Capillaries/mm ²	0,102	NS	0,054	NS
<i>M. infra spinam</i>				
I% _{area}	0,101	NS	-0,084	NS
IIA% _{area}	-0,132	NS	-0,058	NS
IIB% _{area}	-0,046	NS	0,097	NS
CSA _I , 1000 μm^2	0,126	NS	0,043	NS
CSA _{IIA} , 1000 μm^2	0,030	NS	0,050	NS
CSA _{IIB} , 1000 μm^2	0,134	NS	0,081	NS
Capillaries/mm ²	-0,077	NS	-0,153	NS

* p<0.05; NS = non significant