

Short communication

COMPARISON OF *M. SEMITENDINOSUS* MORPHOMETRY AND STRUCTURE IN GILTS AND BARROWS AT MARKET AGE

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The aim of this paper was to investigate the differences in morphometric characteristics and histological structure of *m. semitendinosus*, between gilts and barrows of German Landrace breed at the end of the fattening period. Morphometric characteristics (weight, length, diameter and cross sectional area) of *m. semitendinosus* were not significantly different, while gender as a factor influenced the histological properties of this muscle. A very high statistical difference ($p < 0.01$) in the total number of muscle fibers in *m. semitendinosus* was determined, with gilts having a higher total fiber number. The cross sectional area of fast twitch oxidative (FTO) fibers was significantly higher ($p < 0.05$) in barrows. Gender did not affect the distribution of different fiber types: in both gender, the most present fiber types (48-52 %) were fast twitch glycolytic (FTG), FTO fibers represented 27-30 % of the total fiber number, while slow twitch oxidative fibers (STO) were the least represented (≈ 20 %).

Key words: gender, fiber types, muscle composition, fattening, pigs

INTRODUCTION

Skeletal muscles of adult pigs consist of different types of muscle fibers. Based on ATPase activity, speed of contraction, color and type of metabolism three muscle fiber types could be defined: red, slow twitch oxidative (STO); red, fast twitch oxidative (FTO) and white, fast twitch oxidative (FTG) [1]. The distribution of these fiber types differs in skeletal muscles of the same individual [2,3]. It is therefore possible to define red and white muscles in pigs [4]. Red, dark muscles consist of a higher number of STO and FTO fibers, while in white muscles FTG fibers are dominant. The results on the influence of gender on the number and distribution of fibers within the muscle are contradictory. Some authors [5,6] point out that gender has no influence on the

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distribution of different muscle fiber types. Other authors [7-9] consider gender as a factor affecting the diameter of muscle fibers, with gilts having fibers of a smaller diameter compared to barrows. On the contrary, there are data indicating a larger diameter and fiber girth in gilts compared to barrows [10-12].

The aim of this study was to investigate the differences in structure of *m. semitendinosus*, both morphometrical (weight, length, diameter and cross sectional area) and histological properties (total number of fibers, fiber diameter, distribution of muscle fiber types) of *m. semitendinosus*, between gilts and barrows of German Landrace breed at the end of fattening.

MATERIAL AND METHODS

Animals and feeding

The research was conducted at the experimental station of the Leibnitz Institute for Farm Animal Biology - FBN Dummerstorf, Rostock, Germany. Pigs of German Landrace breed were used for the investigation. All procedures including the use and treatment of animals were in accordance with the guidelines set by the Animal Care Committee of the State Mecklenburg-Vorpommern, Germany, based on the German Law of Animal Protection. Eight multiparous sows were bred to the same German Landrace boar. Sow pregnancy was confirmed at day 28 of gestation by ultrasound. The sows were housed individually, under controlled environmental conditions (temperature 19°C, relative humidity 60-80 %). All animals had free access to water, and were manually fed twice a day with standard soy based concentrate (Denkavit, Trede&Pein GmbH&Co. KG, Itzehohe, Germany). To induce farrowing, on day 114 of pregnancy all sows were injected intramuscularly with 1 ml of a synthetic prostaglandin (cloprostenol, 75 mg/ml: AniMedica West, Chemische Produkte GmbH, Senden, Germany). After birth, the body weight of piglets was recorded. Male piglets were castrated at day 5 after birth, and all piglets were weaned at day 28 of age. During the whole growing-finishing period the offspring was fed ad libitum, with standard commercial starter, grower and finisher feed mixtures. The growing period lasted until 180 days of age, and average market weight of slaughter pigs at the end of fattening was 108.35 kg.

Muscle histology and histochemistry

For histological and histochemical analysis, the left side *m. semitendinosus* was used. Two samples were taken from *m. semitendinosus* of each individual: one sample was taken from the deep dark portion of the mid belly, and the second sample was taken from the superficial light portion of the mid belly. Pieces of the muscle were mounted on cork-chucks and snap frozen in liquid nitrogen. Serial sections were cut at 10 µm in a cryostat, and stained for cytoplasm and nuclei by hematoxylin/eosin [13], or exposed to a combined reaction for NADH-tetrazolium reductase (NADH-TR) [14] and acid preincubated ATPase at pH 4,2 [15], which enables to classify STO, FTO and FTG

muscle fibers. Further image analysis of sections of adult pig muscle was done by AMBA software (AMBA, IBSB, Berlin, Germany). On hematoxylin/eosin stained sections the number of fibers and cross sectional area (FCSA) of individual fibers were determined first, and immediately afterwards the sections stained for fiber types were analyzed. The average values of the investigated parameters calculated from both regions of the muscle were taken for further analysis. TFN was calculated by multiplying the number of fibers/unit area with FCSA.

Statistical analysis

Data were subjected to analysis of variance using the GLM and mixed classification models of SAS (SAS System for Windows Release 8e, SAS Institute Inc., Cary, NC 27513, USA).

RESULTS AND DISCUSSION

The data on morphometric characteristics of *m. semitendinosus* are shown in Table 1. Gender did not influence birth weight. However, body weight at the end of fattening was significantly higher ($p < 0.05$) in barrows.

Table 1. Body weight and *m.semitendinosus* morphometric traits in German Landrace pigs of different gender (LSM \pm SE)

Trait	Gender		P value
	Barrows (n=16)	Gilts (n=15)	
Birth weight, kg	1.38 \pm 0.04	1.22 \pm 0.03	0.20
Slaughter weight, kg	108.17 \pm 1.96	103.27 \pm 0.18	0.05
Morphometric properties of <i>m. semitendinosus</i>			
Weight, g	455.14 \pm 23.45	487.69 \pm 22.95	0.12
Length, cm	22.98 \pm 0.63	24.02 \pm 0.62	0.21
Girth, cm	21.20 \pm 0.45	21.59 \pm 0.44	0.35
Cross sectional area, cm ²	35.88 \pm 1.47	37.16 \pm 1.44	0.37

Morphometric characteristics of *m. semitendinosus* (weight, length, girth and cross sectional area), were not significantly different between gilts and barrows, although all of the observed measurements were higher in gilts.

A high statistical difference ($p < 0.01$) in total fiber number in *m. semitendinosus* was observed in gilts compared to barrows (Table 2).

Both in gilts and in barrows, the most abundant fibers in the muscle were of FTG type (48-52%). FTO fibers represented 27-30% of total fiber number, while the least represented were fibers of STO type ($\approx 20\%$). The cross sectional area of FTO

fibers was significantly higher ($p < 0.05$) in barrows. For STO and FTG fiber types no statistically significant differences were recorded.

Table 2. Effects of gender on muscle fiber number, fiber type distribution (%) and fiber cross sectional area (μm^2) of *m. semitendinosus* in German landrace pigs at market weight (LSM \pm SE)

Trait	Gender		P value
	Barrows (n=15)	Gilts (n=14)	
Total fiber number	876271 \pm 49222.00	1014734 \pm 47407.00	0.01
STO fibers, %	20.68 \pm 1.20	20.23 \pm 1.16	0.77
FTO fibers, %	30.03 \pm 1.75	26.98 \pm 1.68	0.12
FTG fibers, %	48.19 \pm 1.83	51.78 \pm 1.76	0.11
STO fiber area, μm^2	4712.89 \pm 414.36	4257.16 \pm 400.75	0.22
FTO fiber area, μm^2	4357.86 \pm 288.73	3780.99 \pm 273.19	0.05
FTG fiber area, μm^2	3792.26 \pm 188.66	3560.76 \pm 182.19	0.35
Mean fiber area, μm^2	4143.00 \pm 220.45	3757.93 \pm 211.91	0.15

No significant differences were recorded in morphometrical characteristics of *m. semitendinosus* between gilts and barrows of German Landrace pigs. However, for all investigated traits (weight, length, diameter and cross sectional area of the muscle) higher values were obtained for gilts. The analysis of histological structure of this muscle showed significant differences due to gender. The average cross sectional area of muscle fibers was larger in barrows than in gilts, but a statistically significant difference ($p < 0.05$) was determined only for FTO fibers, which is in accordance with results of some authors [7-9], but contradictory to other authors [10-12]. An inverse relationship between the number and cross sectional area of muscle fibers was obtained. The total number of muscle fibers in the *m. semitendinosus* was significantly higher ($p < 0.01$) in gilts, with muscle fibers of smaller cross sectional area.

The distribution of muscle fiber types in *m. semitendinosus* was not significantly different between genders, which is in accordance with results of other authors [7]. There is evidence of a significantly higher percentage of STO fibers in boars than in gilts, but these authors also state that castration leads to a decrease in the percentage of STO fibers [1]. In both gender FTG fibers are the most abundant (48-52%), FTO fibers represented 27-30% of the total fiber number, and STO fibers were the least represented, with approximately 20%, which is in accordance with results of other authors [12,16].

To conclude, gender did not influence morphometric characteristics of *m. semitendinosus*: weight, length, girth and cross sectional area. The analysis of histological structure of the muscle showed significant differences, where a higher total number of muscle fibers was observed in gilts ($p < 0.01$). The cross sectional area of FTO fibers was significantly higher in barrows ($p < 0.05$). The distribution of muscle fiber types in

m. semitendinosus did not differ significantly regarding to gender. Both in gilts and in barrows, fast twitch glycolytic FTG fibers were dominant, while the least represented were fibers of slow twitch oxidative STO type.

Authors' contributions

IB collecting of muscle samples, preparation of samples for histology, microscopy. DV and MB performed statistical analysis. IN and SJ translated article into english. MZ and ZB gathering of references from the field of investigation, formatting the article according to instructions for authors.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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POREĐENJE MORFOMETRIJSKIH I HISTOLOŠKIH OSOBINA *M. SEMITENDINOSUS*-A KOD NAZIMICA I KASTRATA NA ZAVRŠETKU TOVA

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Cilj ovog rada je bio da se ispita postojanje razlika u morfometrijskim osobinama i strukturi *m.semitendinosus*, između ženki i kastriranih mužjaka svinja Nemačkog landrasa, na kraju tova. Morfometrijske osobine (masa, dužina, obim i površina poprečnog preseka) *m. semitendinosus*, nisu bile statistički značajno različite između polova. Histološka analiza strukture mišića je pokazala da postoje neke razlike između polova. Ukupan broj mišićnih vlakana u *m. semitendinosus* bio je veoma značajno ($p<0.01$) veći kod ženki nego kod kastriranih mužjaka. Površina poprečnog preseka FTO vlakana bila statistički značajno veća ($p<0.05$) kod kastriranih mužjaka nego kod ženki. Procentualni udeo (zastupljenost) tipova mišićnih vlakana u *m.semitendinosus*, se nije značajno razlikovao između polova. Kod oba pola najveći udeo (oko polovinu od svih tipova vlakana) su imala bela brzo kontrahujuća glikolitička (FTG) vlakana (48-52 %). Od crvenih, oksidativnih vlakana najmanji udeo (20.23-20.68 %) su imala sporo kontrahujuća (STO) vlakna dok su brzo kontrahujuća (FTO) vlakna bila zastupljena u većem procentu (27-30 %).