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Age-related changes in the carcass composition and meat quality of fallow deer (*DAMA DAMA L.*)

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ABSTRACT

The present study investigated the possible differences in carcass composition as well as texture, structure and percentage of different muscle types of the most valuable muscles (BF – biceps femoris, SM – semimembranosus, and L – longissimus) from fallow deer (*Dama dama* L.) bucks shot in the forest farm in north-western Poland at four different ages: 18, 30, 42 and 54 months. It was found that carcasses of young fallow deer (18–30 months), compared to older animals, were characterised by a higher dressing proportion, a higher percentage of the most valuable commercial cuts (the saddle, haunch and shoulder), high meat yield with the lowest percentage of bones and a lower percentage of skin and head. Their muscles, compared with older animals, were characterised by a lower percentage of red fibres, lower muscle fibre area, thinner perimysium and endomysium, lower amount of intramuscular fat and as a consequence lower hardness, springiness, cohesiveness, as well as a higher pH and lower thermal drip.

1. Introduction

Deer farming, hunting, venison production and consumption has been firmly established in Europe for many years (Piasentier, Bovolenta, & Viliani, 2005). Venison is produced locally in several European countries, particularly in Austria, Germany, Italy, Sweden, Switzerland, the Czech Republic, Norway, Hungary, Slovakia, Spain, and Poland (Audenaerde, 2002; Salghetti, 1999). Fallow deer in particular are chosen as a production species in Europe due to their longevity, disease resistance, and hardiness in winter, ease of calving, as well as high meat quality (Audenaerde, 2002; Salghetti, 1999). This kind of meat can be considered as rich in protein and low in fat, energy and cholesterol (Drew, 1992), and thus as a source of lean and healthy meat (Hoffman & Wiklund, 2006; Wiklund, Dobbie, Stuart, & Littlejohn, 2010). However, as reported by Ferguson et al. (2001) and Hutchison, Mulley, Wiklund, and Flesch (2012), the carcass composition and final culinary quality of meat may be affected by both intrinsic and extrinsic factors, such as genes, sex, and age as well as factors relating to meat production, *i.e.* slaughter, processing and preparation for consumption. These factors are responsible for biophysical and histochemical properties of meat. Thus, for example, researchers such as Ruusunen and Puolanne (2004), Żochowska et al. (2005) and Żochowska et al. (2006) compared muscles of wild boars of different ages, and concluded that muscle structure and fibre composition are specific to different animal species and could be affected by growth rate. Despite an increasing consumer interest in game meat, fallow deer in particular, there is not much information concerning the effect of age on carcass composition and meat quality. Despite the well-known relationships between age and the fibre type composition of meat obtained from farmed and wild animals, there are a lack of studies related to fallow deer meat.

Therefore, the objectives of this study were to compare the effect of age on dressing proportion, composition of commercial cuts as well as fibre type, structure, and texture of the most valuable for meat industry fallow deer muscles. These results help in understanding of the functionality of fallow deer meat farmed in Poland, and to analyse the effect of age on venison quality.

2. Materials and methods

2.1. Harvesting of fallow deer

A total of 28 carcasses from fallow deer bucks (*Dama dama*) of four different ages (seven carcasses in each group) were used. The fallow deer carcasses selected from among the hunted animals weighted

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47 ± 1, 58 ± 2 67 ± 2 and 73 ± 2 kg, while their ages were approximately 18, 30, 42 and 54 months, respectively. The age of fallow deer was determined by tooth wear and replacement on the jaw teeth (Dzierżyńska-Cybulko & Fruziński, 1997). Animals were given unlimited access to a pasture located on the Experimental Farm, which mostly included grass, herbs, trees, and brush. The stock rate was 30 fallow deer/ha. One-shot animals were harvested by experienced and licensed hunters during a winter hunting season within a closed area in the forest of the Western Pomeranian District under the best possible conditions so as to minimise stress (Regulations of Minister of Agriculture and Rural Development, 2005). Animals were bled by cutting the major vessels of the throat, and then immediately exsanguinated, weighed and tagged with an identification number. Hot carcass weight was recorded, after bleeding and removal of abdominal and thoracic viscera, genital organs, skin, head, and feet.

2.2. Dressing and removal of muscles

For the purposes of histochemical analyses, 3 samples of 1x1x0.5 cm were taken from the mid-part of the most valuable and largest muscles: *biceps femoris* (BF), *semimembranosus* (SM), and *longissimus dorsi* (L) of each carcass (30–45 min after being shot), then immediately frozen in liquid nitrogen and stored at −80 °C. The carcasses were transported to the laboratory facilities at the West Pomeranian University of Technology in Szczecin. Approximately 44-h *post mortem,* carcasses were taken from the cool room and weighed (cold carcass weight; SF-912 digital hanging weight, RealHunter Poland). Cold dressing proportion was calculated as a ratio between (Bx100)/A, with (A) representing hot carcass weight, and (B) cold carcass weight. After halving, the right side of each animal was jointed according to the standard of the Polish Department of Hunting into the following cuts: thorax, shoulder, saddle, haunch, and flank. The haunch was used to obtain the following muscles: BF, SM, ST (*semitendinosus*), QF (*quadriceps femoris*), whereas the shoulder and the saddle were dissected into the following muscles: INF (*infraspinatus*), TB (*triceps brachii*) and L, PM (*psoas major*), respectively.

In order to assess the structural elements and texture parameters, approximately 4 cm thick slices were cut perpendicularly to the fibres from the BF, SM and L muscle (four slices from each muscle/animal). The first were used for structural analysis, the remaining 3 slices were weighed, placed separately in plastic bags, cooked in a water bath at 85 °C until the geometric centre reached 68 °C, cooled, re-weighed and stored at 4 °C for 12 h for physical analyses (cooking loss, texture measurements).

2.3. Myofibre classification and measurements

Muscle fibre type measurements were obtained from muscle samples frozen in liquid nitrogen, and cut at −24 °C with a HM 505 EV cryostat. The cuts (10 μm) were placed on glass slides, stained using the myosin ATP-ase method (Guth & Samaha, 1970), and classified according to Brooke and Kaiser (1970) into three groups: type I (slow twitch, oxidative), type IIA (fast twitch, oxidative-glycolitic), and type IIB (fast twitch, glycolytic). The stained sections were examined with an image analysis system with the use of appropriate software (Multi Scan Base v.13). The percentage of type I, type IIA, and type IIB per each muscle fibre bundle was calculated with > 10 bundles being examined per muscle sample. A magnification of 100× was applied. The samples were analysed in duplicate.

2.4. Measurements of structure elements

The mean fibre cross-sectional area (CSA), intramuscular fat area (IMF), as well as the endomysium and perimysium thickness were measured for the raw SM, BF, and L muscles. Three cuts of about 6 × 6 × 10 mm were taken from each muscle, dehydrated in alcohol, fixed in Sannomiya solution, and embedded in paraffin blocks. The blocks were sectioned with a microtome, and sections of 10 μm were placed on glass slides, then contrast-stained (Burck, 1975). The Multi Scan Base v.13 computer image analysis software was used to measure the fibre CSA, and the endomysium and perimysium thickness, per muscle fibre bundle, and 10 primary muscle fibre bundles per each muscle were analysed, furthermore > 200 muscle fibre and endomysium and perimysium thickness/samples were analysed. The area of intramuscular fat was measured along the entire section. A magnification of 100× was applied. The samples were analysed in duplicate.

2.5. Texture measurement

The texture of muscles was evaluated in compliance with the Texture Profile Analysis (TPA) procedure (Bourne, 2002) with an Instron 1140 by driving twice a 0.61 cm diameter shaft parallel to the sample muscle fibre down to 80% of its original height (16 mm). A crosshead speed of 50 mm min^{-1} and a load cell of 50 N were applied. The force-deformation curve obtained during the TPA test was used to calculate the meat hardness, cohesiveness and springiness (Bourne, 2002). The TPA test was repeated 15 times for each sample in duplicate.

2.6. Other physical analyses

Cooking loss (% weight loss) was determined by weighing individual muscles (PS 2100.X2, Radwag, Poland) before and after cooking. Muscle pH (48 h *post mortem*) was measured using a portable pH meter (CP-461, Elmetron, Poland) equipped with a pH penetration probe and an automatic temperature compensation probe. Before each measurement, the pH meter was calibrated with standard buffer solutions of pH 7.0 and pH 4.0 (POCH S.A., Poland) stored at room temperature.

2.7. Statistical analyses

The instrumental measurement data were analysed statistically using the Statistica® v.12.0 PL software with the single effects given by age of animals or muscle and the fixed effects by age, muscle and their interaction. The mean values and standard error of means (SEM) for each sample, as well as the differences in carcass composition, texture, structure, histochemistry, and some physical properties between ages and muscle of fallow deer using RIR-Tukey test are presented in Tables 1–6.

3. Results and discussion

A significant ($P \leq 0.01$) effect of age was observed for carcass weight (hot and cold) and percentage share in the carcass head and skin of fallow deer. The lowest average weight characterised both the hot and the gutted carcasses of 18-month-old animals. The average carcass weight, mass of skins and heads increased significantly with age, almost doubling in 54-month-old bucks, compared to the youngest animal carcasses. No effect of age of the animals on leg weight was found. The best dressing percentage characterised the carcasses of fallow deer at the age of 18 months (50.43%). However, significant differences in the values of these ratios were determined between 18-, and 42- and 54-month-old bucks, while the dressing percentage of carcasses of fallow deer at the age of 30 months did not differ significantly from the other groups. Higher dressing percentage than that presented in the study was reported for Swedish adult reindeer bucks by Wiklund, Nilsson, and Åhman (2000). According to Dzierżyńska-Cybulko and Fruziński (1997), the dressing percentage obtained for wild animals varies widely, which stems not only from the age of the animal, but also the habitat conditions and the amount of available food or the hunting season. Different values obtained by the above mentioned authors may be attributable to the method of calculating game slaughter yield based