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The effect of muscle, time post-mortem and sex on the quality of meat from fallow deer (*Dama dama*) farmed in Poland

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ABSTRACT

The quality of three muscles (*m. supraspinatus, m. longissimus, m. semimembranosus*) was studied in a group of 20 farmed fallow deer bucks and does (*Dama dama*) aged 31 months. The aim of the research was to analyse the functionality of venison from fallows farmed in the western Poland by comparing selected quality traits of three selected muscles during their maturation in vacuum packaging. A significant influence of the period of maturation was found for most of the analysed meat quality traits. The pH values after 8 and 15 days of maturation in vacuum packaging stabilised in a range from 5.54 to 5.61 indicating high quality meat. The most significant fall of pH was observed between the 4th and the 24th hour post-mortem in all the analysed muscles ($P \leq .01$). The redness and chroma, purge in vacuum and the plasticity increased in all the analysed muscles within 15 days of maturation. There was a tendency of an increasing share of dry matter, crude protein and extractable fat, and decreasing W/CP ratio during the chilled storage of venison. Also a significant influence of muscle on the analysed quality traits could be observed. *M. supraspinatus* characterised with the highest pH, and a*, b* and C* colour coordinates ($P \leq .05$). It also characterised the lowest drip loss ($P \leq .01$) measured 24 h and 15 days post-mortem, the highest content of total water ($P \leq .01$), the lowest percentage of dry matter and crude protein ($P \leq .01$) and the highest W/CP ratio. *M. longissimus* characterised with higher purge loss compared to *m. supraspinatus* ($P \leq .01$) and *m. semimembranosus* ($P \leq .01$), and with the highest plasticity. While the highest percentage of free water and the highest share of free water in total water were observed for *m. semimembranosus* ($P \leq .01$). The results indicate high functionality of meat of fallow deer farmed in Poland, with significant differences between the quality of the analysed muscles, and a need to further explore the effect of time of storage on venison from deer farmed in Poland.

1. Introduction

Deer farming in Poland in its present stage started to develop in the year 2002, when farmed deer obtained the status of farmed animals. Currently the most popular species kept on Polish farms are red deer (*Cervus elaphus*) and fallow deer (*Dama dama*). Two types of slaughter are allowed at Polish deer farms: slaughter by a shot in the neck or in the head performed by a qualified hunter (according to Polish Law Gazette 2005, No 33.298) or a slaughter at slaughterhouses especially adapted for this species (currently there is only one legalised deer slaughterhouse in Poland). Unfortunately most deer farms in Poland are not equipped in deer yards used for handling farmed deer. This constitutes a serious problem, as the animals which are not used to regular contact with people and to entering enclosed spaces will not enter the transport truck. As a results on most of the Polish deer farms the animals are shot in-pasture, bleed-out, and then transported to a slaughterhouse (Borys et al., 2012).

Farmed deer have undergone only a limited domestication, which means they are still wild animals highly prone to stress. The pre-slaughter handling of these animals, including road transport, lairage and the slaughter, often constitutes a great source of stress. All stressful procedures connected with the management of farmed deer lead to the depletion of muscle glycogen, and may cause development of low quality, DFD meat (Dark Firm Dry), unfit for maturation in vacuum packaging due to its shorter shelf-life (Wiklund et al., 1995, 2000). Considering the semi-wild production system, the susceptibility of farmed deer to stress, and the in-pasture slaughter popular at Polish deer farms, it can be expected that the post-mortem biochemical processes taking place in the muscles will differ from the ones observed in meat of typical farm species like sheep, cattle or pigs. Fortunately, research conducted on the effect of type of slaughter on the quality of farmed venison indicate, that in case of proper pre-slaughter handling

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the slaughter of farmed deer with a paddock-shot or at commercial slaughterhouse has only minor effect on the venison quality (Pollard et al., 2002).

In order to develop its unique sensory attributes as well as high nutritional and technological quality the deer meat needs to mature. The process of meat maturation (aging) starts after the rigor mortis phase, and covers series of complex biochemical and structural changes, finally leading to development of desirable gamy flavor and aroma, and to meat tenderization (Volpelli et al., 2005; Koohmaraie and Geesink, 2006). Venison has stronger taste and characteristic texture different from farm animals, but its considered as healthier and dietetic meat useful for processing (Cenci-Goga et al., 2012).

The aim of the study was to analyse the quality of meat (*m. supraspinatus, m. longissimus, m. semimembranosus*) from fallow deer farmed in Poland, after a period of maturation in vacuum packaging. The research hypothesis assumed that the time span in vacuum packaging will affect the technological quality of farmed venison. These type of studies help to define the functionality of this raw material produced under conditions of Polish climate and under specific regulations of deer farming in Poland, and to analyse the effect of farming management on the quality of deer meat.

2. Material and methods

2.1. Fallow deer pre-slaughter management

The study was conducted on a group of 10 farmed fallow deer bucks and 10 does (*Dama dama*), aged about 31 months, raised on a deer farm located in the western Poland. The animals were kept in a larger group on a common pasture at a stocking density of 12 animals/ha. The slaughter of animals took place in January. The animals' diet was based on the pasture forage, but because of the winter season they were additionally fed maize silage, haylage and were provided straw *ad libitum*. The animals were randomly slaughtered in-pasture with a shot (Regulations of Minister of Agriculture and Rural Development, Polish Law Gazette no. 33.298, 2005) and bleed out by cutting the major vessels of the throat. Within three hours post-mortem the animals were transported to a slaughter house and dressed. Half an hour after dressing, the carcasses were placed in the chilling room at +1 °C.

2.2. Post-slaughter procedures

2.2.1. Sample acquisition

At 24 h post-mortem the chilled deer carcasses were weighted. The right-side *musculus longissimus, muculus semimembranosus,* and *musculus supraspinatus* were boned from the carcasses. Each muscle was divided into two proportional parts. One part was used to analyse the quality of deer meat 24 h post-mortem. The remaining parts of the muscles were weighted and packaged in vacuum pouches with 70 µm thick walls, using the TEPRO vacuum packer PP4.2. The vacuum-packaged samples were stored for 7 and 14 days at +2 °C and then analysed (on the 8th and 15th day post-slaughter; 8d and 15d).

2.2.2. Meat pH

The pH of each of the three muscles was measured by inserting into the meat a temperature compensated combination glass calomel electrode (ERH-11 × 1) connected to a portable pH-meter (Handylab 2, SCHOTT). The first measurement of pH and temperature was taken just before placing the carcasses in the chilling conditions (4 h post-mortem) in the right-side *m. longissimus, m. semimembranosus,* and *m. supraspinatus.* The pH measurements were repeated 24 h (24 h), 8 days (8 d) and 15 days (15 d) post-mortem.

2.2.3. Colour

The first colour measures on each venison sample were recorded 24 h post-mortem prior to vacuum packaging on a freshly cut surface. Each sample was allowed to bloom for 45 min at +4 °C before colour was measured using a Minolta colorimeter CR-200b (illuminant C, 10° observer with a 30 mm-diameter aperture size) on the tristimulus CIE system which measures L* (lightness), a*(redness) and b* (yellowness) (CIE, 1978). Colour measures were repeated at 8 d and 15 d post-mortem after storage at 1 °C and removal from vacuum packages, on freshly cut muscles after 45 min of blooming. The chroma and hue-angle values were calculated according to the formulas:

$$\text{Chroma} = (a^{*2} + b^{*2})^{1/2}$$

$$\text{Hue angle} = \tan^{-1}(b^*/a^*)$$

2.2.4. The capacity to hold residual water

The capacity of each muscle sample to hold residual water was determined 24 h post-mortem (drip loss and cooking loss) and after 8 and 15 days post-mortem (purge in vacuum bags, drip loss and cooking loss).

- The purge in the vacuum bags (%). The muscle parts prepared for storage were weighted before packaging in vacuum bags and re-weighted after removing them from vacuum bags (8 or 15 days post-mortem) and drying from excessive moisture with paper towels.
- The drip loss (%) was measured after Honikel (1998). The 2.5 cm thick, transverse slices of the three analysed muscles (about 50–70 g) were weighed, hung on hooks and placed in a container to reduce evaporation (+4 °C). After 24 h the samples were weighed again in order to calculate the change in the weight of the sample.
- The cooking loss (%) was measured after Honikel (1998). The 2.5 cm thick, transverse slices of the three analysed muscles (about 50–70 g) were placed in thin polyethylene bags with the bag's wall firmly adhered to the meat sample. The bags with meat were placed in the water bath at 75 °C for 30 min, and then cooled to the room temperature and re-weighted after removing the excess of moisture with a paper towel. The change in the weight of the sample was calculated (%).

2.2.5. The water fractions and plasticity

For the analysis of the content of different water fractions and chemical composition muscle samples were minced in a food grinder.

- Total water content (%) 3 g samples of minced meat were dried in filter paper bundles at 105 °C to a constant weight (PN-ISO 1442, 2000).
- The free water (%) was measured using a filter paper press method, after Grau and Hamm (1953) in modification of Pohja and Niinivaara (1957). In this method 0.3 g samples of ground meat were placed on a filter paper between two glass tiles. A force of 2 kg was applied on each sample for 5 min, and the samples were removed from the filter paper and weighted straight after in order to calculate the change in the weight of the sample (free water%) and the meat area (cm^2), which was deducted from the whole area of the pressed sample (free water cm^2).
- The plasticity (cm^2) was measured according to Grajewska et al. (1984) on the same samples used for measuring the percentage of free water with a filter paper press method. After removing the weight the surface of meat was outlined. The meat area was measured with ImageJ ver. 1.50f 3 (2015).

2.2.6. Chemical composition

To dry matter content was determined on the basis of the total water content. Crude protein content was determined by the Kjeldahl procedure (PN-A-04018, 1975). Ground meat samples were weighted (0.3-0.5 g), packed in the cellophane paper and stored at −20 °C until the day of analysis. The frozen samples were subjected to the process of digestion in the K-424 Buchi digestion unit. The samples