The effect of gender on meat (Longissimus lumborum muscle) quality characteristics in the fallow deer (Dama dama L.)

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Abstract

The aim of this study was to determine the quality of meat (Longissimus lumborum muscle) from male (11 bucks) and female (10 does) fallow deer (Dama dama L.) aged 17-18 months, hunter-harvested in north-eastern Poland during one hunting season. Muscle samples collected from the carcasses of male fallow deer were characterized by a higher (P<0.01) content of dry matter, protein, fat and energy, and a lower (P<0.01) water/protein ratio than male counterparts. An analysis of the fatty acid profile revealed that the intramuscular fat of female fallow deer contained higher levels of C16:0 and C17:1 fatty acids (P<0.01), and C16:1, ≤0.01), and C14:0, C17:0 and C20:4 fatty acids (P<0.05), and higher (P<0.01) pH and greater (P<0.01) drip loss, ≤0.01) contri-

Introduction

Recent years have witnessed an increased interest among consumers and producers in alternative, original and natural (organic) food products, including wild game meat, which have also been the focus of a growing body of research (Hoffman and Wiklund, 2006; Dahlan et al., 2008). Over the past few years, the quality of venison has been analyzed in view of various factors such as animal species (Zuchowska-Kujawska et al., 2009), sex (Daszkiewicz et al., 2009, 2012; Purchas et al., 2010; Dominik et al., 2012), age (VolPELLi et al., 2003; Dannenberger et al., 2013) and dietary regime (Wood et al., 2003; Wiklund et al., 2006). Due to the problems with collecting a sufficient number of samples characterized by uniform quality, most of the research in the field involves the most commonly hunted big game species (red deer, roe deer, wild boar) (Ramanzin et al., 2010) and game species raised on farms (red deer, fallow deer) (VolPELLi et al., 2002, 2003; Wood et al., 2003, Wiklund et al., 2004, 2005, 2010; Purchas et al., 2010; Hutchison et al., 2012; Triumf et al., 2012). It should be noted, however, that meat from other wild animal species is also available on the market. One of such species is the fallow deer (Dama dama L.). Fallow deer are both hunted in the wild and raised by farmers (Dahlan et al., 2008; Hutchison et al., 2010, 2014). Therefore, it seems justified to investigate the quality attributes of fallow deer meat and to identify the key factors influencing those attributes. In addition to expanding the existing knowledge, research findings could contribute to the advertising and promotion of fallow deer meat among consumers, and could be implemented in technological processes in meat processing plants.

The objective of this study was to determine the effect of gender on the quality of meat from fallow deer (Dama dama L.) hunter-harvested in north-eastern Poland.

Materials and methods

The experimental materials comprised samples of the Longissimus lumborum (LL) muscle, collected from male (11 bucks) and female (10 does) fallow deer (Dama dama L.) aged 17-18 months. The carcasses were supplied to the LAS OLSZTYN meat processing plant Sp.20.0. Ltd. in Olsztyn (Poland). All animals were hunter-harvested in north-eastern Poland (S popol Plain, Region of Warmia and Mazury) in November and December of the same hunting season. The age of fallow deer was estimated by hunters based on the wear of mandibular premolars and molars (Morow, 1993) and on the fact that calving took place in June and July of the year preceding the experiment. The time that passed from the harvest of animals to carcass cutting at the meat processing plant was 48 to 54 hours. The time of harvest was determined based on hunter harvest reports. All analyzed carcasses were characterized by: no bullet damage to the Longissimus dorsi (LD) muscle, no carcass contamination due to damage to the digestive tract (bullet damage or incorrect evisceration procedure), correct carcass chilling (temperature measured at the geometric center of the thickest portion of the leg - not higher than 7°C), pH of the LL muscle (measured behind the last rib) between 5.4 and 5.8.

Samples of the LL muscle cut off of the right side of each carcass (behind the last rib) were packaged in polyethylene bags and transported to the laboratory in isothermal containers with ice. The samples were analyzed to determine the proximate chemical composition, fatty acid profile, physicochemical and sensory properties of meat. The analysis of the proximate chemical composition of meat included the determina-
tion of dry matter content (by drying at 105°C to constant weight), total protein content by the Kjeldahl method, crude fat content by the Soxhlet method (extraction with diethyl ether as the solvent) and ash content (by incineration at 550°C to constant weight) (AOAC, 1990). The energy value of meat (100 g) was calculated with the use of individual energy factors for protein - 4.00 kcal (16.78 kJ)/g and fat - 9.00 kcal (37.62 kJ)/g (Jankowska et al., 2005).

The fatty acid profile of intramuscular fat was determined by gas chromatography using a VARIAN CP-3800 gas chromatograph equipped with a flame ionization detector (FID) and a capillary column (length - 50 m, inner diameter - 0.25 mm, bonded liquid phase – 100% cyanopropyl siloxane, film thickness - 0.25 mm). The carrier gas was helium (flow rate – 1.2 ml/min). The oven temperature was programmed from 50°C to 200°C (35 min). The temperature of the injector and the detector was set at 225°C and 250°C, respectively. Fatty acid methyl esters were extracted by the modified method of Peisker (Żegarska et al., 1991).

Before carcass dressing, the pH of the LL muscle was measured behind the last rib to eliminate DFD meat, with the use of a combination Double Pore electrode (Hamilton Bonaduz AG, Bonaduz, Switzerland) and a 340i pH-meter equipped with a TFK 150/€ temperature sensor (WTW Wissenschaftlich-Technische Werkstätten GmbH, Weilheim, Germany). The pH of meat was measured in the laboratory, in water homogenates (meat to water ratio -1:2) at 962°C. The ultimate temperature inside the sample was 80°C. Approximately 1-cm³ cubes of meat was cut from the middle of each cooked sample and wrapped in aluminum foil. Coded meat samples were presented to the panelists at room temperature. Distilled water was made available to the panelists for mouth cleansing between samples. All sensory attributes (aroma, taste, juiciness and tenderness) of each sample were evaluated during a single session. A maximum of five meat samples were assessed per session.

The shear force of meat (5 samples, cylinders 1.27 cm in diameters and 2 cm in height) was determined using a Warner-Bratzler head (500 N, speed 100 mm/min.) attached to an INSTRON 5542 universal testing machine. The preparation of meat samples and the measurement of shear force performance were described as performed by Honikel (1998).

A statistical analysis was performed using the STATISTICA ver. 10 application (StatSoft, 2011). To determine the effect of gender on the proximate chemical composition, fatty acid profile and physicochemical properties of the LL muscle in fallow deer, the results were analyzed using Student’s t-test. Sensory panel data were analyzed by analysis of variance with gender as the fixed effect and panelists as the random effect (Duncan’s test was carried out to determine differences between groups).

**Results and discussion**

An analysis of LL muscle samples collected from fallow deer carcasses revealed significant sex-related differences in the proximate chemical composition of meat (Table 1). The meat of male fallow deer was characterized by a higher (P≤0.01) dry matter content (a difference of 0.81 percentage points), which resulted from a higher (P≤0.01) protein and fat content (differences between mean values of 1.03 and 0.20 percentage points, respectively). The fat content of fallow deer meat was very low (<0.5 %), despite a statistically significant difference between males and females. The differences in protein and fat content contributed to a higher (P≤0.01) energy value and a lower (P≤0.01) water/protein ratio in meat from bucks (Table 1).

The proximate chemical composition of fallow deer meat determined in our study is similar to that reported by other authors who also noted a high total protein content and a low fat content in meat from fallow deer (Volpelli et al., 2003; Bureš et al., 2015) and other species of the family Cervidae (Purchas et al., 2010; Postolache et al., 2011; Dąszkiewicz et al., 2012; Dominik et al., 2012; Dannenberger et al., 2013). In a study by Bureš et al. (2015), the lipid content of the LL muscle in male fallow deer reached 0.81%, and it accounted for ¼ of the total fat content of meat from young Aberdeen Angus and Holstein bulls. A lower lipid content of the *Longissimus thoracis et lumbrorum* muscle (0.56-0.72) in male fallow

### Table 1. Proximate chemical composition and energy value of meat (*Longissimus lumbrorum* muscle) from male and female fallow deer (*Dama dama L.*) (means ± SEM).

|                | Female (doe) n=10 | Male (buck) n=11 | P  |
|----------------|-------------------|-----------------|----|
| Dry matter, %  | 24.90±0.21        | 25.71±0.13      | 0.003 |
| Fat, %         | 0.30±0.05         | 0.50±0.04       | 0.008 |
| Total protein, %| 21.76±0.19        | 22.79±0.11      | 0.001 |
| Ash, %         | 1.07±0.01         | 1.10±0.03       | 0.361 |
| W/P            | 3.49±0.04         | 3.39±0.02       | 0.001 |
| Energy value, kJ| 378.42±4.73       | 401.97±2.25     | 0.001 |

W/P, water/protein ratio. Values within a row with different superscript letters are significantly different.
deer was reported by Volpelli et al. (2003).

Some studies have found that gender has a significant effect on the content of protein (Daszkiewicz et al., 2012), fat (Dominik et al., 2012; Triunf et al., 2012) and minerals (Postolache et al., 2011) in cervid meat. However, the available original research articles provide no information about differences in the chemical composition of meat between male and female fallow deer living in the wild, most probably due to difficulties in obtaining representative experimental material (uniform in terms of age, time and place of harvest). The population of wild fallow deer is much smaller than the populations of other cervid species (red deer, roe deer), which is why the harvest rates of fallow deer are also much smaller than the populations of other cervid species (red deer, roe deer), which is why the harvest rates of fallow deer are also lower - 7,252 animals in the 2012/2013 hunting season in Poland (Central Statistical Office, 2013).

In the human diet, meat is a source of saturated fatty acids, which are associated with an increased risk of lifestyle diseases (Wood et al., 2003). However, it should be stressed that meat contains also n-3 fatty acids that are necessary for human health (Cordain et al., 2002).

Male and female fallow deer differed in their fatty acid profile of intramuscular fat, including the ratio of polyunsaturated fatty acids (PUFAs) to saturated fatty acids (SFAs) (Table 2). The meat of male fallow deer contained higher average concentrations of lauric acid (C12:0), arachidic acid (C20:0), linoleic acid (C18:2) and eicosenoic acid (C20:1) (P≤0.01) as well as palmitoleic acid (C16:1) and -linolenic acid (C18:3) (P≤0.05). The meat of female fallow deer contained higher levels of palmitic acid (C16:0), margaric acid (C17:0) (P≤0.01), myristic acid (C14:0), margaric acid (C17:0) and arachidononic acid (C20:4) (P≤0.05) as well as higher (P≤0.01) total SFA concentrations. Such a relationship between gender and the fatty acid profile of the LD muscle was also observed in the red deer by Purchas et al. (2010) and in the roe deer by Dannenberger et al. (2013). The cited authors demonstrated that meat from female animals had a higher content of total SFAs, in particular C14:0, C16:0 and C17:0 fatty acids, and that the predominant SFAs were C16:0 and stearic (C18:0) fatty acids. Different results were reported by Polak et al. (2008) who found that the meat of red deer stags contained higher (P≤0.05) amounts of C16:0 fatty acid and lower (P≤0.05) levels of C18:0 fatty acid, in comparison with the meat of hinds and calves. In our study, meat from male fallow deer had higher (P≤0.05) PUFA concentrations. A higher PUFA content of meat from males than females was also observed in other cervid species by Daszkiewicz et al. (2012) (roe deer), Polak et al. (2008) and Purchas et al. (2010) (red deer).

The differences in the concentrations of the analyzed fatty acids in the LL muscle of male and female fallow deer were reflected in the PUFA/SFA ratio, which was higher (P≤0.01) in the meat of males, although the difference between mean values in groups reached only 0.09 points. Such a correlation between gender and the PUFA/SFA ratio was also noted by Polak et al. (2008) and Purchas et al. (2010), who analyzed red deer meat (Semitendinosus and Longissimus dorsi muscles, respectively). The fatty acid profile of meat is affected by the animal’s diet and – in ruminants – also by the fact that unsaturated fatty acids are partially hydrogenated by ruminal bacteria. As a result, the PUFA/SFA ratio is often lower than the optimal value of ≥0.4 (Wood et al., 2003).

An analysis of the physicochemical properties of meat revealed that samples of the LL muscles collected from male fallow deer had a lower (P≤0.01) pH (5.53) than those obtained from females (5.68) (Table 3). However, the difference between mean values was only 0.15 units, and its statistical significance resulted most probably from low variation in the analyzed trait. Hutchison et al. (2014) did not observe significant (P>0.05) differences in muscle quality of the fallow deer

| Table 2. Fatty acid concentrations (% total fatty acids) and the polyunsaturated fatty acid to saturated fatty acid ratio in intramuscular fat of Longissimus lumborum muscle from male and female fallow deer (Dama dama L.) (means ± SEM). |
|------------------------|------------------------|------------------------|------------------------|
| Sex                    | Female (doe) n=10      | Male (buck) n=11        | P                      |
| C12:0                  | 0.15±0.02              | 0.73±0.12               | 0.001                  |
| C14:0                  | 5.48±0.07              | 4.33±0.47               | 0.015                  |
| C14:1                  | 0.51±0.03              | 0.71±0.13               | 0.109                  |
| C15:0                  | 1.74±0.06              | 1.59±0.23               | 0.514                  |
| C16:0                  | 34.55±0.04             | 29.42±0.96              | 0.001                  |
| C16:1                  | 3.34±0.24              | 4.55±0.41               | 0.024                  |
| C17:0                  | 2.23±0.08              | 1.83±0.14               | 0.023                  |
| C17:1                  | 2.88±0.20              | 0.78±0.14               | 0.001                  |
| C18:0                  | 18.51±0.47             | 17.26±0.98              | 0.238                  |
| C18:1                  | 18.92±0.32             | 23.36±1.92              | 0.021                  |
| C18:2                  | 5.78±0.41              | 10.18±0.71              | 0.001                  |
| C18:3                  | 1.68±0.08              | 2.10±0.20               | 0.047                  |
| C20:0                  | 0.04±0.00              | 0.28±0.03               | 0.001                  |
| C20:1                  | 0.06±0.01              | 0.30±0.06               | 0.001                  |
| C20:4                  | 3.74±0.32              | 2.58±0.35               | 0.027                  |
| SFA                    | 63.09±0.62             | 55.44±1.55              | 0.001                  |
| MUFA                   | 25.71±0.38             | 29.40±2.13              | 0.075                  |
| PUFA                   | 11.19±0.75             | 14.86±1.14              | 0.013                  |
| PUFA/SFA               | 0.18±0.01              | 0.27±0.02               | 0.001                  |

| Table 3. Physicochemical properties of meat (Longissimus lumborum muscle) from male and female fallow deer (Dama dama L.) (means ± SEM). |
|------------------------|------------------------|------------------------|------------------------|
| Sex                    | Female (doe) n=10      | Male (buck) n=11        | P                      |
| pH                     | 5.68±0.01              | 5.53±0.01               | 0.001                  |
| L*                     | 29.88±0.91             | 30.01±0.56              | 0.907                  |
| a*                     | 12.33±0.28             | 16.37±0.47              | 0.001                  |
| b*                     | 8.13±0.46              | 11.13±0.56              | 0.001                  |
| C*                     | 14.07±0.48             | 19.81±0.69              | 0.001                  |
| h*                     | 33.36±0.98             | 34.02±0.66              | 0.581                  |
| Drip losses, %         | 1.81±0.12              | 2.79±0.30               | 0.009                  |
| Water-holding capacity, cm² | 5.40±0.49           | 5.26±0.24               | 0.778                  |
| Cooking losses, %      | 31.94±1.23             | 33.45±0.44              | 0.244                  |

L*, lightness; a*, redness; b*, yellowness; C*, chroma; h, hue. *Values within a row with different superscript letters are significantly different at P≤0.05; **Values within a row with different superscript lowercase letters are significantly different at P≤0.05.
the pH of meat (Longissimus thoracis et lumbarum muscle) from farm-raised female and male fallow deer (5.73 vs. 5.80). The effect of gender on the pH of the LL muscle was not noted by Daszkiewicz et al. (2012) in the roe deer or by Purchas et al. (2010) in the red deer. Colour is one of the most important quality attributes of meat - it gives an initial impression of a product and therefore has a major impact on the purchase decisions made by consumers (Font-i-Furnols and Guerrero, 2014). According to Hoffman et al. (2005), the muscles of wild animals work hard and are used in motor activities, which is why they contain high amounts of myoglobin responsible for their characteristic dark color. Myoglobin content is also affected by residual blood (hemoglobin) present in the muscle tissue due to insufficient bleeding of the carcass.

No significant (P>0.05) differences were noted in the average values of colour parameter L* (lightness) between LL muscle samples collected from male and female fallow deer (Table 3). The colour of meat from bucks had a higher (P=0.01) contribution of redness (a*) and yellowness (b*), and higher saturation (C*).

There is a general lack of published data on the influence of sex on meat colour in fallow deer, although Hutchison et al. (2014) demonstrated that in farmed fallow deer, the colour of the Longissimus thoracis et lumbarum muscle was darker in males than in females. The relationship between gender and meat colour has been investigated in more detail in other cervid species. In a study by Purchas et al. (2010), the LL muscle of red deer stags was lighter in colour (higher values of parameter L*) than the meat of hinds (P=0.05). Daszkiewicz et al. (2009) reported higher values of L*, b* and C* in the LL muscle of female red deer. Dominik et al. (2012), noted higher (P≤0.01) values of colour parameter a* in the LD muscle of male roe deer.

Table 4. Sensory properties and shear force values of meat (Longissimus lumbarum muscle) from male and female fallow deer (Dama dama L.) (means ± SEM).

| Property         | Female (doe) n=10 | Male (buck) n=11 | P    |
|------------------|-------------------|-----------------|------|
| Aroma-intensity  | 4.20±0.23         | 4.14±0.23       | 0.848|
| Taste-intensity  | 4.00±0.17         | 4.27±0.12       | 0.199|
| Juiciness        | 3.35±0.21         | 4.00±0.13       | 0.016|
| Tenderness       | 4.60±0.15         | 3.86±0.15       | 0.002|
| Shear force, N   | 19.17±1.81        | 22.05±1.65      | 0.253|

Sensory properties are expressed in a 5-point scale: 5 points is the highest score, while 1 point is the lowest score. *Values within a row with different superscript uppercase letters are significantly different at P<0.01; *Values within a row with different superscript lowercase letters are significantly different at P<0.05.

Samples of the LL muscle collected from male fallow deer were characterized by higher average (P≤0.01) natural drip loss in comparison with samples obtained from females (difference of 0.98 percentage points) (Table 3). However, drip loss values varied widely in the meat of bucks. No significant differences were noted in the cooking loss or water-holding capacity (determined by the Grau and Hamm method) of meat from male and female fallow deer (Table 3). A tendency towards higher cooking loss was observed in the meat of bucks (difference of 1.51 percentage points). The differences in the water-holding capacity of meat between male and female fallow deer were most likely due to differences in average pH levels. In the meat of does, the pH was more distant from the isoelectric point of proteins, which therefore could bind water molecules more efficiently. As a result, natural drip loss decreased, although it was not confirmed by forced drip loss values.

Sensory properties are important quality attributes of meat. Wild game meat has a specific taste and aroma because it comes from animals living under natural conditions (Kwiatkowska et al., 2009).

The analyzed fallow deer meat was characterized by very good sensory quality (Table 4), and it received lower scores only for juiciness. Gender had a significant (P≤0.05) effect on juiciness, which was higher in meat from bucks. Meat from does received higher scores for tenderness (P≤0.01), which corresponded with lower shear force values (the difference was not statistically significant).

Higher tenderness of meat from female fallow deer probably resulted from its higher pH which promoted the activity of the calpain system, including non-lysosomal proteolytic enzymes (Sentandreu et al., 2002). Higher juiciness of meat from bucks is more difficult to explain. It could be related with its higher fat content, which remained very low, but was nearly two-fold higher than in meat from does. Higher juiciness could also be associated with a higher content of intramuscular fat rich in PUFAs. Such a relationship was reported by Niedziółka and Pieniak-Lendzion (2005), and Zelenka et al. (2008). The cited authors analyzed the fatty acid profile of goat meat and poultry meat, respectively, and found that meat with a higher PUFA content was more juicy.

Conclusions

The analyzed fallow deer meat (Longissimus lumbarum muscle) had a high nutritional value due to its high (approx. 25%) total protein content and a low average fat content (below 0.5%). Meat from bucks and does was characterized by desirable sensory properties and a dark colour, typical of venison.

The quality of fallow deer meat was affected by gender. Meat from bucks had a higher dry matter, protein and fat content. It was characterized by higher concentrations of UFA (including PUFA), a lower pH, higher colour saturation (due to higher contribution of redness and yellowness), higher juiciness, and higher aroma desirability. Meat from does was characterized by lower natural drip loss and higher tenderness.

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