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THE COMPARISON OF MEAT QUALITY FROM DIFFERENT CARCASS CUTS OF MALE FALLOW DEER (*DAMA DAMA* L.)

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Key words: fallow deer, carcass cuts, meat quality.

Abstract

The aim of this study was to compare the quality of meat from four carcass cuts (neck, saddle, shoulder and leg) in 10 male fallow deer (*Dama dama* L.) aged between 4 and 5 years. The animals were hunter-harvested in the forests of north-eastern Poland.

Lower moisture content in meat from the saddle and neck resulted from a higher protein and fat content, as compared with meat from the shoulder and leg. The meat from the saddle had the lowest pH and the darkest color. Meat from the shoulder and neck had a lower water-holding capacity (WHC) and higher values of a^* (redness) than meat from the leg and saddle. The highest value of b^* (yellowness) was noted in meat from the neck, and the lowest in meat from the saddle.

PORÓWNANIE JAKOŚCI MIĘSA POCHODZĄCEGO Z RÓŻNYCH ELEMENTÓW TUSZY DANIELA (*DAMA DAMA* L.)

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Słowa kluczowe: daniel, elementy tuszy, jakość mięsa.

Abstrakt

Celem badań było porównanie jakości mięsa z czterech zasadniczych elementów tuszy (karkówki, combra, łopatki i udźca) 10 byków daniela (*Dama dama* L.) w wieku 4–5 lat, odstrzelonych przez myśliwych w lasach północno-wschodniej Polski.

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Mniejszy udział wody w mięsie z combra i karkówki wynikał ze stwierdzonej w nim większej, niż w mięsie z łopatki i udźca, zawartości białka i tłuszczu. Mięso z combra charakteryzowało się najniższą wartością pH i najciemniejszą barwą. Z kolei mięso z łopatki i karkówki odznaczało się mniejszą zdolnością utrzymywania wody własnej oraz większą wartością *a** (czerwoność) w porównaniu z mięsem z udźca i combra. Najwyższą wartość *b** (żółtość) stwierdzono w mięsie z karkówki, a najniższą w mięsie z combra.

Introduction

Game meat is of great interest to both researchers and producers. Recent years have witnessed an increasing demand for high-quality, easily digestible meat products characterized by a high nutritional value and superior sensory properties (RESURRECCION 2003). Modern consumers often show a preference for organic and welfare-labeled meat from animals raised under conditions that most closely resemble their natural environment (WIKLUND et al. 2005). Available literature (HOFFMAN and WIKLUND 2006) data show that venison meets this "naturality" requirement and high consumer expectations. Venison has a high content of protein, vitamins and bioactive compounds (SAMPLES et al. 2006, PURCHAS et al. 2010), a low content of fat with a desirable fatty acid profile (VOLPELLI et al. 2003, POLAK et al. 2008), and a specific taste and aroma referred to as sour, grassy or simply "wild" or "gamey" (HOFFMAN and WIKLUND 2006).

Despite the unquestionable advantages of venison, it should be noted that the quality of meat obtained from different parts of game carcasses may vary with respect to, among others, its basic chemical composition and physicochemical properties (pH, color, water-holding capacity) (PAULSEN et al. 2005, DASZKIEWICZ et al. 2011, 2013). This is an important consideration for meat processing plants and consumers as it will affect the processing suitability and culinary use of meat. In view of the above, the objective of this study was to compare the quality of meat from different carcass cuts of male fallow deer (*Dama dama* L.) hunter-harvested in north-eastern Poland.

Materials and Methods

Materials

The experimental materials comprised the carcasses of 10 fallow deer (*Dama dama* L.) bucks aged 4 to 5 years, supplied to a meat processing plant. The animals were hunter-harvested (ambush tactics, a heart shot) in the forests of north-eastern Poland (Sępopol Plain, Region of Warmia and Mazury) during one hunting season (in November and December). The age of bucks was estimated by hunters, based on the appearance of their antlers and the wear of mandibular premolars and molars. The animals were bled and eviscerated in the field immediately after shooting. After bleeding and evisceration, the beheaded carcasses (with the skin and legs) were transported by hunters (within 2–3 h of harvest) to a cold store where they were stored at 2–4°C, and next they were transported in a refrigerator truck to the meat processing plant. In the meat processing plant carcasses were stored at a temperature ranging from 0°C to 2°C.

The time that passed from the harvest of animals to carcass cutting was 48 to 54 hours (time of harvest was determined based on hunter harvest reports). Each carcass was divided into primal cuts in the meat processing plant, in accordance with Polish industry standard *Mięso z dziczyzny*... BN-84/9241-10. Four cuts from each carcass, i.e. the saddle, neck, shoulder and leg, were then trimmed to obtain lean meat. Meat from each cut was cut into small pieces (weight ca. 10 g), and thoroughly mixed. Average samples (approx. 300 g) of meat from each cut (from each carcass) were collected (forty samples of meat: 4 cuts of each animal × 10 animals). The samples were packaged in polyethylene bags and transported in containers with ice to the laboratory where they were deep-frozen at –26°C and stored until analysis.

Preparation of meat samples

Prior to meat quality evaluation, the samples were thawed at 2°C until their internal temperature reached -1°C. The samples were put through a laboratory mincer with a 3 mm diameter mesh plate three times. Minced meat was mixed thoroughly, and the obtained samples were analyzed to determine the basic chemical composition and physicochemical properties of meat.

Research methods

The analysis of the basic chemical composition of meat included the determination of moisture content (samples were dried at 105°C to constant weight), total protein content – by the Kjeldahl method, fat content – by the Soxhlet method and ash content (by incineration at 550°C to obtain a constant weight) (AOAC 1990). The water to protein ratio of samples was calculated as W/P, where W = average moisture percentage of the sample and P = average protein percentage of the sample.

The energy value of meat (in conversion per 100 g of meat) was calculated with the use of individual energy factors for protein – 16.78 kJ g^{-1} and fat – 37.62 kJ g^{-1} (JANKOWSKA et al. 2005).

The pH of samples was measured in the water homogenates of 10 g meat (meat and distilled water ratio of 1:1) using a combination Polilyte Lab electrode (Hamilton) and a 340i pH-meter equipped with a TFK 325 temperature sensor (WTW).

The instrumental color analysis was based on measurement (three times) of light reflected from different points of meat surface and later transformed into values in the CIE (1978) L^*, a^*, b^* color system. An automated HunterLab MiniScan XE Plus spectrocolorimeter (Hunter Associates Laboratory Inc., Reston, VA, USA) was used to register L^* (lightness), a^* (redness) and b^* (yellowness) values. Prior to the measurement, samples wrapped in oxygen-permeable and water-impermeable foil were stored for 0.5 h at 4°C. The values of C^* (chroma) were calculated from the following formula: $C^* = (a^{*2} + b^{*2})^{1/2}$.

The water-holding capacity (WHC) of meat was determined by the Grau and Hamm method (VAN OECKEL et al. 1999).

Statistical analysis

The data were processed statistically by one-way ANOVA using Statistica ver. 10 software (StatSoft, Inc. 2011). The significance of differences between means in groups was estimated by Duncan's multiple range test.

Results

Basic chemical composition of meat

An analysis of the basic chemical composition of meat obtained from four primal cuts of fallow deer carcasses (Table 1) revealed that meat from the shoulder had a higher ($P \leq 0.01$) moisture content than meat from the neck, leg and saddle. Meat from the saddle had the lowest moisture content, and the noted differences were statistically significant ($P \leq 0.01$) relative to meat from the shoulder and leg, as well as from the neck ($P \leq 0.05$). Lower moisture content in meat from the saddle and neck resulted from higher protein and fat content, as compared to meat from the shoulder and leg. Meat from four primal cuts had similar average concentrations of mineral compounds in ash form. The differences between mean values determined for meat from the saddle vs. from the shoulder and leg were significant ($P \leq 0.05$), but very small (0.06 and 0.05 percentage points, respectively). The significance of differences between means in groups could be due to the low variability of the analyzed trait.

Table 1

Basic chemical composition and energy value of muscle tissue from different carcass cuts of male fallow deer (means ± SEM)

Traits [%]	Carcass cuts			
	shoulder (n = 10)	neck (n =10)	leg (n = 10)	saddle (n = 10)
Moisture	77.18 ± 0.22^{A}	75.84 ± 0.20^{Ba}	76.06 ± 0.24^{C}	75.25 ± 0.07^{Bb}
Fat	0.60 ± 0.08^{A}	1.19 ± 0.07^{B}	0.66 ± 0.06^{A}	1.04 ± 0.08^{B}
Protein	20.99 ± 0.19^{A}	22.40 ± 0.21^{BCa}	21.83 ± 0.21^{Bb}	22.68 ± 0.06^{C}
Ash	1.02 ± 0.02^{a}	1.04 ± 0.01^{ab}	1.03 ± 0.02^{a}	1.08 ± 0.01^{b}
Water/protein ratio (W/P)	3.68 ± 0.04^{A}	3.39 ± 0.04^{B}	3.49 ± 0.04^{B}	3.32 ± 0.01^{C}
Energy value [kJ 100 g^{-1}]	375 ± 3.84^{A}	421 ± 4.34^{B}	391 ± 3.89^{C}	420 ± 3.42^{B}

SEM – the standard error of the mean.

^{ABC} – differences between values with different letters in the same rows are significant ($P \leq 0.01$).

^{ab} – differences between values with different letters in the same rows are significant ($P \leq 0.05$).

The differences in the content of moisture, protein and fat in meat were reflected in the differences in the water to protein (W/P) ratio and the energy value of meat (Table 1). The W/P ratio was highest in meat from the shoulder, and lowest in meat from the saddle. Meat from the neck and saddle was characterized by the highest ($P \leq 0.01$) energy value, and the lowest ($P \leq 0.01$) from the shoulder.

Physicochemical properties of meat

The analyzed meat was characterized by high average pH levels (Table 2). Meat from the saddle had the lowest pH value (5.77), which was lower ($P \leq 0.01$) than the pH value determined in meat from the other three cuts.

Meat from the saddle had the darkest color ($P \leq 0.01$) – Table 2, followed by meat from the leg, shoulder and neck. The color of meat from the neck was lighter ($P \leq 0.01$) than from the saddle, leg and shoulder. Meat from the shoulder and neck had a significantly higher values of parameter a^* (redness) in comparison with meat from the saddle and leg (Table 2). Differences ($P \leq 0.01$) were observed in average values of b^* (yellowness) between meat from the analyzed primal cuts (Table 2). The highest value of b^* was noted in meat from the neck, and the lowest from the saddle.

Table 2
Physicochemical properties of muscle tissue from different carcass cuts of male fallow deer (means ± SEM)

Traits	Carcass cuts			
	shoulder (n = 10)	neck (n =10)	leg (n = 10)	saddle (n = 10)
pH	5.92 ± 0.03^{A}	5.90 ± 0.02^{A}	5.87 ± 0.02^{A}	5.77 ± 0.01^{B}
L* (lightness)	34.06 ± 0.50^{A}	38.95 ± 0.78^{B}	33.14 ± 0.36^{A}	30.48 ± 0.35^{C}
a* (redness)	17.04 ± 0.41^{A}	16.55 ± 0.42^{ABa}	15.49 ± 0.39^{BCb}	14.46 ± 0.23^{B}
b* (yellowness)	14.38 ± 0.25^{A}	15.85 ± 0.24^{B}	13.05 ± 0.29^{C}	11.81 ± 0.24^{D}
C* (saturation)	22.31 ± 0.43^{Aab}	$22.93. \pm 0.43^{A}$	20.26 ± 0.47^{Ba}	18.67 ± 0.32^{Bb}
Water – holding capacity (WHC) – Grau and Hamm method [cm^2 g^{-1}]	22.49 ± 1.09^{Aa}	22.09 ± 0.99^{Aa}	17.74 ± 1.19^{B}	18.78 ± 0.82^{b}

SEM – the standard error of the mean.
^{ABCD} – differences between values with different letters in the same rows are significant (P = 0.01).
^{ab} – differences between values with different letters in the same rows are significant ($P \leq 0.05$).

Differences in the mean values of parameters a* and b* were reflected in differences in color saturation (C*) between the groups (Table 2). Meat from the neck and shoulder was characterized by the highest color saturation, and the lowest from the saddle ($P \leq 0.01$). The difference ($P \leq 0.05$) in color saturation between meat from the leg and saddle was also noted.

In our experiment, muscle tissue from the shoulder and neck had a lower ($P \leq 0.01$) WHC (Table 2), compared to meat from the leg and saddle.

Discussion

Basic chemical composition of meat

The results of the present study were similar to these obtained by VOLPELLI et al. (2003) who also stated a high protein and a low fat content in male fallow dear meat from different muscles. The above mentioned authors reported that total protein and fat content ranged from 21.56 up to 21.78% and 0.56–0.72%, respectively (*m. longissimus thoracis et lumborum)* as well as from 20.46 up to 20.90% and 0.55–0.78%, respectively (*m. semitendinosus)*. DAHLAN and NORFARIZAN HANOON (2008) reported that protein content of the *longissimus dorsi*, *psoas major* and *biceps femoris* muscles of farmed fallow was 22.77, 21.16 and 20.91%, respectively, and fat content 6.13, 9.23 and 9.39%, respectively. The results of studies involving other wild cervid species (PAULSEN et al. 2005, DASZKIEWICZ et al. 2011) also revealed differences in the protein and fat content of meat obtained from different carcass parts.

Physicochemical properties of meat

In the present study meat from all the cuts had a high pH values. BRODOWSKI and BEUTLING (1991) noted lower average pH value (5.58) for the *semimembranosus* muscle of fallow deer shot by hunters. VOLPELLI et al. (2003) and HUTCHISON et al. (2012) reported pH values 5.5–5.6 in meat (*m. longissimus dorsi* and *m. semimembranosus*) from farmed fallow deer. High average pH values of meat (*m. longissimus dorsi*) from the carcasses of farm-raised fallow deer were noted by WIKLUND et al. (2004) (54.5% of samples had pH ≥ 6.2). SHAW (2000) reported that pH value of *m. semimembranosus* and *m. longissimus dorsi from* farm-raised fallow deer was 5.86 and 5.70, respectively. The noted differences in the ultimate pH of the meat of both wild and farmed fallow deer could be attributed to pre-slaughter stress factors and the animals' reproductive cycle.

Differences in the color of meat obtained from different carcass parts of fallow deer bucks may be due to the fact that the muscles that work harder and are used in motor activities contain higher amounts of myoglobin (LAWRIE 1998). This explains the higher values of a^*, b^* and C^* parameters of meat from the neck and shoulder, compared to meat from the saddle and leg. Our results do not confirm the well-known relationship between the pH value and meat color (WARRISS 2010). Meat from the saddle, which had the lowest pH (5.77), had the lowest value of L^* parameter too. The differences in average pH values between groups were statistically significant, but small (the largest difference reached 0.15 pH units). Therefore, the possible influence of pH levels on the results of instrumental measurements of lightness (L^*) could have been masked by the effects of other factors such as the proportions of adipose and connective tissues and the content of residual blood (hemoglobin), which depends on the degree of carcass bleeding.

An increase pH value of meat is usually accompanied by higher WHC (WARRISS 2010), what was not observed in the present study. It seems that the lower WHC of meat from the shoulder depended from a low content of protein that is responsible for water binding, whereas the lower water-holding of meat from the neck was due to a high content of fat that prevents direct contact between protein with water, thus reducing water binding.

Conclusions

To sum up, the results of our study confirm that fallow deer meat has a high nutritional value (high total protein content, low fat content). The present results indicate also that the quality of meat from four primal cuts of fallow deer carcasses (saddle, neck, shoulder, leg) differs significantly in regard of basic chemical composition, pH value, color (L^*, a^*, b^*) and water-holding capacity. The differences in the quality of meat from cuts of fallow deer carcasses should be taken into account by game meat processing plants and consumers.

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