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THE EFFECT OF SEX ON THE DRESSING PERCENTAGE, CARCASS, AND ORGAN QUALITY IN THE FALLOW DEER (*DAMA DAMA*)*

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Abstract

Basic carcass characteristics, the quality traits of meat and internal organs from 10 fallow deer bucks and 10 does aged from 31 to 32 months were investigated. No sex effects on the bled body weight, meat yield and carcass composition were found. A significantly higher weight of mesenteric and omental fat (by 0.44 kg) was found for does. The combined share of muscle and fat in the carcass parts ranged from 77.9 to 78.5%, and the share of bones from 21.5 to 22.1%. No sex effects were found for the pH and water holding capacity measurements. Venison from males was characterized by a significantly higher thermal drip value (P=0.043) and higher L* (P=0.026), a* (P=0.010) and b* (P=0.036) values compared to does. The extracted fat content was significantly higher for females compared to males (P=0.009). The chemical analysis of deer edible by-products indicated the highest level of protein for the liver (17%), and the highest level of dry matter and fat for the tongue (33–34% and 15–18%, respectively).

Key words: fallow deer, sex, venison quality, carcass quality

Diseases characteristic of modern Western civilization are very common. One of the deciding factors influencing the development of cardiovascular diseases and causing overweight in people, is a diet rich in saturated fatty acids (Hu and Willett, 2002). Today, the modern consumer has become more conscious about the influence of food on human health. In the meat industry, this awareness has caused a growth in the consumption of nutritionally valuable venison (Volpelli et al., 2002). Deer is a species which, compared to traditional livestock breeds, was skipped in the intensive breeding system typical of today's meat industry. Animals kept on deer

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farms eat vegetation. For these deer, food concentrates are used mainly to improve the condition of the animals during the winter period (Bovolenta et al., 2013). The pasture-based, extensive system, though, does not always assure the proper slaughter traits of animals. For this reason, some venison producers incorporate activities like castration and the use of feed concentrate, which are typical, intensive meat production activities. These activities are meant to increase the profitability of deer farming (Hudson, 2000). There is a risk that such procedures may decrease the venison quality. That is why all efforts should be made to retain healthy aspects of venison. Both the positive and negative impact of deer farming procedures on the deer industry must be studied. Research carried out in the field of meat science could help to balance the nutritional and sensory qualities of venison with the economical profitability of deer farming. The deer meat market is quite a new branch in the meat industry. Venison is not as commonly available in meat marketing as pork or beef. The physicochemical traits of venison have not been as thoroughly studied as the characteristics of the traditionally-farmed animal meat. Therefore, the main focus of the presented research is to increase the existing information available on fallow deer meat and some physical and chemical characteristics of the edible by-products. We also analysed differences in the meat performance of fallow bucks and does. The research hypothesis was that both fallow deer meat and internal organs have a high technological and nutritional quality.

Material and methods

Fallow deer pre-slaughter management

The study was conducted on a group of 20 farmed fallow deer (*Dama dama*) including 10 males and 10 females, aged from 31 to 32 months. The animals were assigned to two very similar paddocks (the same botanical composition) of one pasture. The summer forage was based on the pasture vegetation. The winter diet was based on grass haylage (*ad libitum*) and grain (oats, barley, maize in equal proportions). Each animal was provided 0.5 kg grain per day, irrespective of sex. In the summer and winter periods, the fallow deer had constant access to water and mineral salts (salt lick). The slaughter took place in the first week of February, in subzero temperatures, in order to prevent meat spoilage during the post-slaughter transport. The slaughter involved shooting the animals (Polish Law Gazette 2005, No 33.298). Directly after shooting the animals were bled-out and transported to the slaughterhouse, weighed (to within an accuracy of 0.1 kg), and eviscerated (all within three hours from slaughter). The body weight of fallows after bleeding-out has been designated as the bled body weight (BBW).

Characteristics of the carcass and non-carcass parts

After dressing (removal of hide, and internal organs) the carcasses were weighed. The following non-carcass products were weighed separately: the head (without antler, cut between the base of skull and the first cervical vertebrae), the tongue, skin,

front feet (cut between the carpal and metacarpal bones), hind feet (cut between the tarsal and metatarsal bones), full gastro-intestinal tract, fat depots (omental, mesenteric, and perinephric fat depots), and internal organs (diaphragm, spleen, lungs, heart, liver, kidneys). All the non-carcass products were weighed to an accuracy of 0.1 kg. The dressing percentage was calculated on the basis of the hot carcass weight and the bled body weight.

The carcasses were cut into half-carcasses. The left side of each carcass was split into the following commercial cuts: shoulder, scrag end, loin, ribs together with flank, and leg. First the shoulder was separated with a curved cut in accordance with the shape of the scapula bone, along the anterior part of the lateral wall of the thorax (from the sternal end of the first rib to the level of the fourth thoracic vertebrae). The scrag (the cranial end) was separated between the occipital bone and the first cervical vertebra. The flank was separated from the ribs with a cut made ventrally along the line of ribs. The second cut was made caudally between the second and third thoracic vertebra. The loin was cut cranially between the second and third thoracic vertebra. The cut was made caudally between the last lumbar vertebra and the first sacral vertebra, towards the hip bone. Then, a cut was made detaching the muscles from the hip bone. These half-carcass parts were weighed to within a 1 g accuracy, and their percentages in the cold carcass weight were calculated. All the commercial cuts were dissected by separating the bones (together with sinews) from the combined muscle and fat tissues.

Analysis of deer meat physicochemical traits

The analysis of fallow deer meat included: pH, colour (L*, a*, b*), water holding capacity measured with the pressure method (WHC), thermal drip (TD) and chemical composition (dry matter, fat and total protein content). The analysis of internal organs included: pH and chemical composition (dry matter, fat and total protein content).

The characteristics of fallow venison were analysed using the samples of *m. semimembranosus* collected from the carcasses after a 24-hour chilling period at 1 to 2°C. The evaluation of organ quality was made on samples from the heart (after removal of the epicardial adipose tissue), the tongue, and the kidneys. Acidity (pH) was measured in the *m. semimembranosus,* and four by-products: the tongue, liver, heart, and kidneys, at 6 hours (pH_6), and 24 hours (pH_{24}) after slaughter. Acidity was evaluated using a combination glass calomel electrode. For the duration of the research, all the collected samples were kept at 1 to 2°C. Twenty-four hours after slaughter, the meat colour was expressed by the CIE tristimulus system which measures L* (lightness), a* (redness), and b* (yellowness) values. The colour space parameters were measured by the reflectance method using a Minolta Colorimeter CR-200b, with an illuminant C, a 10° observer, and a 30 mm-diameter aperture size at one point (the samples had a uniform appearance) of *m. semimembranosus* cross-section (in the widest part), after a bloom period of 10 min. The chemical composition of meat was analysed to determine water content – the samples were dried at 105°C to a constant weight (PN-ISO 1442. 2000), crude fat was determined according to Soxhlet (PN-ISO 1444, 2000), and crude protein according to Kjeldahl (PN-A-04018, 1975). The

thermal drip (TD) was measured after Honikel (1998). The 2.5 cm thick, transverse slices of *m. semimembranosus* (about 50–70 g) were placed in polyethylene bags with the bag's wall firmly adhering 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 weighed in order to calculate the change in the weight of the sample (%). The water holding capacity (WHC) was measured using a pressure method, after Grau and Hamm (1953) in modification of Pohja and Niinivaara (1957). Small samples of ground meat (0.2–0.4 g) 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 weighed straight after in order to calculate the change in the weight of the sample (%).

Statistical analysis

The effects of sex on the bled body weight, hot carcass weight, dressing percentage, the weights of carcass parts, selected internal organs, mesenteric and omental fat, perinephric fat, the tissue composition of carcass parts, the water holding capacity (pressure method), thermal drip and colour (L*, a*, b*) of meat, were calculated using the ANOVA of SAS ver. 9.1 software package (SAS, 2001):

$$Y_{ij} = \mu + \alpha_i + e_{ij}$$

where:

μ – the overall mean of analysed trait,

α_i – the fixed effect of i^{th} sex (i=1, 2),

e_{ij} – the random error.

The effects of sex and the point of measurement (five points: *m. semimembranosus*, tongue, heart, liver and kidneys) on the pH (pH_6, pH_{24}) and chemical composition (dry matter, total protein, extracted fat) were calculated with the linear mixed model given below. Tukey-Kramer adjustment was made for multiple comparisons of LS-mean differences. The analyses were done with SAS ver. 9.1 software package (SAS, 2001):

$$Y_{ijkl} = \mu + \alpha_i + \pi_{j(i)} + \beta_k + \alpha\beta_{ik} + e_{ijkl}$$

where:

μ – the overall mean of analysed trait,

α_i – the fixed effect of i^{th} sex (i=1, 2),

$\pi_{j(i)}$ – the random effect due to the j^{th} individual in the i^{th} sex (j=1, 2, …, 10),

β_k – the effect of k^{th} point of measurement as the repeated measures factor (k = 1, 2, 3, 4, 5),

$\alpha\beta_{ik}$ – the effect of interaction between factors,

e_{ijkl} – the random error.

The Pearson correlation coefficients were calculated (SAS, 2001) from among the carcass quality traits when data for males and females were combined.

Results

No significant differences were found between male and female fallow deer for the bled body weight, dressing percentage and most of the analysed carcass items (Table 1). However, does had a higher weight of mesenteric and omental fat (by 0.44 kg, P=0.029). The weight of the kidneys, heart, and tongue and hot carcass weight (HCW) did not vary between the sexes (Table 2). The fallow bucks had a significantly higher liver weight (by 0.239 kg, P=0.049) compared to females.

Table 1. The effect of sex on the mean bled body weight, carcass weight, dressing percentage (relative to bled body weight), and weights of carcass parts and non-carcass sub-products

Items		Male n = 10	Female n = 10	Effect of sex (P-value)
BBW[c] (kg)	LSM ± SE	51.4±5.2	47.8±3.8	0.589
HCW[c] (kg)	LSM ± SE	33.0±3.7	30.3±2.7	0.565
Dressing percentage (hot) (%[b])	LSM ± SE	63.3±1.1	63.3±0.8	0.984
Front feet (kg)	LSM ± SE	0.66±0.05	0.57±0.04	0.165
Hind feet (kg)	LSM ± SE	0.78±0.06	0.66±0.04	0.135
Head (kg)	LSM ± SE	2.41±0.27	1.87±0.20	0.131
Skin (kg)	LSM ± SE	4.31±0.48	3.93±0.35	0.531
Other organs[a] (kg)	LSM ± SE	2.92±0.27	2.50±0.19	0.218
Gastro-intestinal tract (full) (kg)	LSM ± SE	5.79±0.44	6.01±0.32	0.698
Mesenteric and omental fat (kg)	LSM ± SE	0.65±0.14	1.09±0.10	0.029*
Perinephric fat (kg)	LSM ± SE	0.35±0.05	0.46±0.04	0.121

* P≤0.05.
[a] other organs: trachea, lung, heart, liver, diaphragm, kidneys, spleen.
[b] % bled body weight.
[c] BBW – bled body weight ; HCW – hot carcass weight.

Table 2. The effect of sex on the weight of the internal organs

Items		Male	Female	Effect of sex (P-value)
Liver (kg)	LSM ± SE	0.951±0.107	0.712±0.079	0.049*
Kidneys (kg)	LSM ± SE	0.115±0.011	0.103±0.007	0.405
Heart (kg)	LSM ± SE	0.408±0.035	0.358±0.026	0.275
Tongue (kg)	LSM ± SE	0.157±0.011	0.144±0.008	0.311

* P≤0.05.

Table 3. The effect of sex on the proportion (%) of carcass parts in the carcass weight

Items		Male	Female	Effect of sex (P-value)
Leg (%)	LSM ± SE	35.2 ± 0.7	35.5 ± 0.6	0.747
Loin (%)	LSM ± SE	17.7 ± 0.5	17.9 ± 0.4	0.746
Shoulder (%)	LSM ± SE	16.7 ± 0.3	16.7 ± 0.2	0.952
Ribs with flank (%)	LSM ± SE	16.6 ± 0.5	16.7 ± 0.4	0.824
Scrag (%)	LSM ± SE	13.7 ± 0.8	13.1 ± 0.6	0.557

There were no effects of sex on the percentage of carcass parts (Table 3). No differences between males and females were found for the combined portions of muscle and fat tissue and the bone portion in the carcass. The combined amount of muscle and fat in particular carcass parts ranged from 72.3 to 81.4%, and the share of bones from 18.6 to 27.7% (Table 4).

Table 4. The effect of sex on the composition (%) of the whole carcass and carcass parts in terms of dissected components

Items	Male		Female		Effect of sex (P-value)	
	meat and fat (%) LSM ± SE	bone (%) LSM ± SE	meat and fat (%) LSM ± SE	bone (%) LSM ± SE	meat and fat	bone
Carcass composition	77.9±0.3	22.1±0.3	78.5±0.3	21.5±0.3	0.149	0.146
Leg	80.0±0.5	20.0±053	80.1±0.4	19.9±0.4	0.908	0.907
Loin	75.5±0.6	24.5±0.6	76.2±0.5	23.8±0.5	0.429	0.428
Shoulder	80.8±0.6	19.2±0.6	81.7±0.4	18.3±0.4	0.257	0.253
Ribs with flank	77.7±0.8	22.3±0.8	79.3±0.6	20.7±0.6	0.157	0.156
Scrag	72.1±0.8	27.9±0.8	72.5±0.6	27.5±0.6	0.746	0.732

Table 5. The effect of sex and the point of measurement on the pH values

Points of measurement	Male		Female		Effect of sex (P-value)	
	pH_6 LSM ± SE	pH_{24} LSM ± SE	pH_6 LSM ± SE	pH_{24} LSM ± SE	pH_6	pH_{24}
M. semimembranosus	5.43 A±0.02	5.54 A±0.12	5.42 A±0.02	5.52 A±0.12	0.841	0.241
Liver	5.93 B±0.02	5.95 BC±0.12	5.93 B±0.02	5.96 B±0.12	0.999	0.998
Kidneys	6.43 C±0.02	6.22 B±0.12	6.43 C±0.02	6.52 BC±0.12	0.998	0.608
Heart	6.37 C±0.02	6.33 B±0.12	6.45 C±0.02	6.44 BC±0.12	0.574	0.999
Tongue	5.77 D±0.02	5.74 AC±0.12	5.77 D±0.02	5.79 AB±0.12	0.883	0.999

Means for the points of measurements within the same column with different alphabetical letters (A, B, C, D) were significantly different ($P \leq 0.01$).

There were no effects of sex on the pH value of the analysed measurement points, considering both pH measurements: 6 (pH_6, P=0.435) and 24 (pH_{24}, P=0.217) hours after slaughter. The pH_6 value of the kidneys and the heart did not vary significantly in both sexes. While in the case of other points of measurement significant differences were found in the pH_6 value of both sexes ($P \leq 0.01$). No significant differences were found between the pH_{24} of tongue and the pH_{24} of *m. semimembranosus* and liver, as well as between the pH_{24} of kidneys and heart, in both sexes (Table 5).

The research indicates the effects of sex on the content of dry matter (P=0.035) and extractable fat (P=0.009) in the investigated points of measurement. Sex did not affect the content of protein in the analysed points of measurement (P=0.284). From among the five analysed points of measurement, the tongue of females was found to have a higher level of dry matter (P=0.003) and extractable fat (P=0.001) compared to males. For both sexes the tongue had a significantly higher content of dry matter ($P \leq 0.01$) and extractable fat ($P \leq 0.01$) compared to *m. semimembranosus,* liver, kidneys and heart. For both sexes the protein content in *m. semimembranosus* ($P \leq 0.01$) was higher compared to liver, kidneys, heart and tongue (Table 6).

Table 6. The effect of sex and the point of measurement on the content of dry matter (DM), protein (CP), and extractable fat (EF)

Points of measurement	Male			Female			Effect of sex (P-value)		
	DM LSM ± SE	CP LSM ± SE	EF LSM ± SE	DM LSM ± SE	CP LSM ± SE	EF LSM ± SE	DM	CP	EF
M. semimembranosus	25.3 A±0.6	22.3 A±0.4	0.66 A±0.39	25.8 A±0.6	22.1 A±0.4	1.10 A±0.39	0.998	0.689	0.426
Liver	26.9 A±0.6	17.8 B±0.4	0.78 A±0.39	26.9 A±0.6	17.4 B±0.4	0.98 A±0.39	0.999	0.351	0.720
Kidneys	19.8 B±0.6	14.5 Ca±0.4	0.67 A±0.39	20.3 B±0.6	15.9 Ba±0.4	1.17 A±0.39	0.583	0.164	0.353
Heart	20.4 B±0.6	16.3 D±0.4	0.91 A±0.39	20.9 B±0.6	17.0 Bb±0.4	1.10 A±0.39	0.489	0.125	0.735
Tongue	31.2 C±0.6	15.4 CDb±0.4	15.03 B±0.39	34.5 C±0.6	15.7 Ba±0.4	18.16 B±0.39	0.003**	0.998	0.001***

DM – dry matter, CP – crude protein, EF – extractable fat.
The means for the points of measurements within the same column with different alphabetical letters (a, b) were significantly different (P≤0.05).
The means for the points of measurements within the same column with different alphabetical letters (A, B, C, D) were significantly different (P≤0.01).
** P≤0.01; *** P≤0.001.

Table 7. The effect of sex on the water holding capacity (WHC) measured with the pressure method, thermal drip (TD), and the colour space parameters of the *semimembranosus* muscle

Items		Male	Female	Effect of sex (P-value)
WHC (%)	LSM ± SE	32.4±0.6	33.4±0.6	0.257
TD (%)	LSM ± SE	27.4±0.4	26.4±0.4	0.043*
L*	LSM ± SE	40.1±0.7	37.8±0.7	0.026*
a*	LSM ± SE	13.4±0.4	11.9±0.4	0.010**
b*	LSM ± SE	7.5±0.4	6.2±0.4	0.036*

* P≤0.05; ** P≤0.01.

Table 8. The coefficients of the Pearson correlation for carcass quality indicators. (P-value)

	pH_{24}	WHC	TD	L*	a*	b*	DM	CP
WHC	–0.067 (0.778)							
TD	0.285 (0.224)	–0.174 (0.464)						
L*	0.448 (0.041*)	–0.248 (0.291)	0.177 (0.456)					
a*	0.085 (0.723)	0.117 (0.622)	0.078 (0.743)	0.512 (0.021*)				
b*	0.630 (0.001***)	0.395 (0.048*)	0.314 (0.177)	0.473 (0.034*)	0.405 (0.047*)			
DM	–0.554 (0,010**)	0.210 (0.373)	0.010 (0.763)	–0,174 (0.465)	–0.065 (0.784)	–0.264 (0.322)		
CP	0.062 (0.796)	0.347 (0.133)	–0.047 (0.764)	–0.331 (0.153)	–0.111 (0.642)	0.431 (0.043*)	–0.136 (0.568)	
EF	–0.343 (0.342)	0.209 (0.375)	0.072 (0.764)	–0.369 (0.109)	–0.441 (0.040*)	–0.318 (0.216)	0.731 (0.0004***)	–0.179 (0,448)

* P≤0.05; ** P≤0.01; *** P≤0.001.

WHC – water holding capacity measured with the pressure method, TD – thermal drip, DM – dry matter, CP – crude protein, EF – extractable fat.

There were no differences between the WHC of bucks and does (P=0.257). While a higher TD was noted for the venison of males (P=0.043) compared to females (Table 7). The meat colour analysis indicated that fallow buck venison had a higher L* (P=0.026), a* (P=0.010) and b* (P=0.036) values compared to those of the does (Table 7). The Pearson correlation coefficients for the analysed venison physicochemical traits were calculated (Table 8). A significant correlation was observed between pH_{24} and the dry matter content in the *m. semimembranosus* (r=–0.554, P≤0.01), between pH_{24} and L* (r=0.448, P≤0.05), pH_{24} and b* (r=0.630, P≤0.001). The WHC showed a moderate correlation with b* (r=0.396, P≤0.05). Moderate (from r=0.405 to 0.512, P≤0.05) correlations were observed between the meat colour indicators (L*, a*, and b*). Among the relations between meat colour indicators and other meat characteristics, a moderate negative correlation was recorded between a* and the muscle fat content (r=–0.441, P≤0.05), as well as for b* and muscle protein content (r=0.431, P≤0.05).

Discussion

The characteristics obtained in the presented study on fallow deer carcasses of males are in agreement with those obtained by Volpelli et al. (2002) for 30-month-old fallow bucks with a body weight of 53.3 kg. The animals showed similar values of hot carcass weight (32,6 kg) and dressing percentage (60.9%), head weight (2.42 kg), skin weight (3.66 kg), and other organs weight (2.56 kg) to the fallow males analysed in the current study. The analysis of fallow deer BBW, HCW, and dressing percentage showed no differences between sexes. The analysis of non-carcass fat depots revealed a higher mesenteric and omental fat weights in female fallow deer when compared to the males. Mojto and Kartusek (1993) reported a lower weight and percentage of liver, heart, and perinephric fat, and a lower weight and percentage of the kidneys for fallow deer aged from 22 to 23 months. The aforementioned differences were probably due to the younger age of the animals analysed by Mojto and Kartusek (1993). Fallow bucks in the present research had significantly higher weight of the liver ($P \leq 0.05$). Most of the research on other species of ruminants, like sheep and goats, indicate no effects of sex on the liver weight (Mioč et al., 2013), and on the weight of visceral organs in general (Bonvillani et al., 2010). However Peña et al. (2005) found that sex affected the weight of the visceral organs of sheep, and that males were characterized by a significantly higher weight of the red offals ($P \leq 0.05$) and white offals ($P \leq 0.01$) compared to females, with no indication of specific internal organs responsible for that difference. No significant sex effects on the percentage contribution of commercial cuts were found in the present investigation. The percentage of anatomical joints reported in the present study differed from the results obtained by Volpelli et al. (2002), though in both cases the age and the slaughter weight of the animals were much alike. The difference may be due to a different way of jointing the deer carcasses.

The muscle acidity measured 24 hours after slaughter (females pH_{24}=5.52, males pH_{24}=5.54) was in accordance with the results of other research concerning fallow deer meat quality (Wilkund et al., 2004, 2005). Wilkund et al. (2004) reported a wide range of pH (5.56–6.63) for the fallow deer. Hutchison et al. (2012) observed higher pH values (5.69–5.80), however the measurement was taken on a different muscle (*m. longissimus dorsi*). There were no sex effects on the pH_{24} measured on the *semimembranosus* muscle and internal organs. This is in accordance with the results of investigations dealing with the meat quality of roe deer (Daszkiewicz et al., 2012; Purchas et al., 2010). As for the internal organs, the kidneys had the highest pH_6 (6.43) and the tongue had the lowest pH_6 (5.77). After 24 hours from the slaughter the pH value of the kidneys was still higher compared to other analysed internal organs, and the pH for the tongue was the lowest. Significant differences were found for the pH measurements (pH_6 and pH_{24}) between the analysed points of measurement (*semimembranosus* muscle and organs), mainly due to the differences in their histological structure. Similar effects of the points of measurement (muscles and internal organs) on pH value were reported by Stanisz et al. (2015) in the research on goats. The value of TD recorded for fallow deer males was similar to the results obtained by Volpelli et al. (2003) for 30-month-old fallow males (TD=27.35%), and

it was within a range (25.65–30.19%) presented by Cifuni et al. (2014). The TD of venison analysed in the current study was slightly higher for males compared to females (P=0.043), which is in accordance with the findings of Purchas et al. (2010) concerning red deer (29.62% vs. 28.26%). The studies on roe deer showed no effects of gender on the venison TD (Daszkiewicz et al., 2012). The results of TD measurement presented in the current study may be considered as an indicator of the higher physicochemical quality of the meat produced by females. Lower TD is an indicator of greater meat capacity to hold water during thermal processing. The loss of moisture negatively affects the meat juiciness and nutritional value, because the solution that is lost from postmortem muscle contains a significant amount of protein (Savage et al., 1990).

The research conducted by Mulley et al. (2006) on the consumer liking of deer venison showed that the meat from does (36 months old) was scored significantly higher compared to the venison from fallow bucks (18–24 months old), although the doe meat was darker. Translating this observation into instrumental measurements, the survey indicates that the colour parameters of venison produced by does: L* ranging from 21.91 to 22.37, a* ranging from 12.93 to 13.98, and b* ranging from 1.43 to 1.84, were preferred by consumers to the colour parameters of the venison produced by bucks with lower a* (from 11.58 to 12.28) and b* (0.084 to 0.122). The L* and b* values reported in our study were much higher compared to colour parameters of the fallow venison highly rated by consumers in the research conducted by Mulley et al. (2006). This may lead to a conclusion about too bright colour of the venison analysed in the present study which may not meet the consumer expectations. Moreover the *semimembranosus* muscle from bucks had slightly higher values of the colour space parameters: L* (P=0.026), a* (P=0.010), and b* (P=0.036), compared to *semimembranosus* muscle from does. Higher muscle brightness of the meat from fallow bucks found in this study should not be connected with the content of intramuscular fat, since a higher level of this fat was found in the meat from does (P=0.009). Purchas et al. (2010) reported higher L* parameter for the meat from red deer stags compared to meat from hinds (39.7 vs 38.6; P=0.013) with no difference in a* and b* colour parameters. Conversely, Daszkiewicz et al. (2012) reported no effects of sex on the colour of roe deer meat. The extracted fat content in the venison from fallow deer was generally low in the present study which is in accordance with the results of similar investigations of deer meat (Daszkiewicz et al., 2012; Purchas et al., 2010; Polak et al., 2008) and confirms the high dietetic value of fallow deer meat. A higher fat content for fallow deer meat was observed by Dahlan and Norfarizan Hanoon (2008), most probably due to different age of animals (30–38 months), and different types of analysed muscles (*m. longissimus* and *biceps femoris*) compared to our study. The presented analysis of the proximal composition of meat shows that fallow bucks have a lower extracted fat content (P=0.009), and consequently less DM (P=0.041) compared to does. A significantly lower fat level in male venison was also reported in roe deer by Daszkiewicz et al. (2012) (0.83% in males vs. 1.46% in females) and in red deer by Purchas et al. (2010) (0.63% vs. 1.12%). While Polak et al. (2008) found that sex affected the fat content in *m. semitendinosus* with no difference between sexes for *m. triceps brachii*. Since the amount of intramuscular fat has

been proven to influence meat tenderness and flavour (Schwab et al., 2006; Wood et al., 1999), venison from fallow females has a chance to gain higher consumer acceptance than meat produced by males. Daszkiewicz et al. (2012) reported that in roe deer, sex also influenced the total protein content (21.84% in males vs. 22.79% in females) in venison. However, sex did not influence the protein level in fallow meat analysed in the current study (P=0.620). From among the analysed internal organs the highest amount of fat was found in the tongue. For females the fat level in the tongue was significantly higher compared to males (18.16 vs. 15.03%, P=0.010). Simultaneously the tongue was characterized by the highest content of dry matter, significantly higher for females compared to males (34.5 vs. 31.2%, P=0.048). The highest content of protein was found in the liver (above 17%), with no difference between sexes (P=0.443). Considering the relations between physical and chemical traits of fallow deer venison, no significant correlation (r=0.072, P=0.764) was found between the percentage of extracted fat and the thermal drip of the analysed muscle. This is in accordance with Stevenson et al. (1992), who reported a similar result for the *m. semimembranosus* of red deer stags. A slight correlation was recorded between a* and fat (r=–0.441, P=0.040). Significant correlations between the pH_{24} and L* (r=0.448, P=0.041), pH_{24} and b* (r=0.630, P=0.001) value of the *semimembranosus* muscle are promising, as the pH measured 24 hours after slaughter may be used as the venison colour indicator. The research on the post-slaughter biochemical changes in muscles indicates a strong influence of pH changes on the level of myoglobin oxygenation, which is related with the meat colour space parameters (Ledward, 1992; Price and Schweigert, 1987). As the colour of meat strongly influences the consumer acceptance of culinary meat (Faustman and Cassens, 1990), this observation is considered as important.

Conclusions

The results indicate a high physical and chemical quality of both the fallow deer meat and edible by-products. The differences found in the colour space parameters, thermal drip and fat content in the meat of fallow bucks and does, may result in different processing properties and technological usefulness of products obtained from the different sexes. The meat yield and the portion of commercial carcass parts did not differ between sexes so that similar levels of venison production from fallow males and females can be expected. However the growth rates and the efficiencies of growth may influence the profitability of farming fallow males and females, and their effect on venison production should be taken into consideration in further research.

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