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Quality Indicators of Roe Deer (*Capreolus capreolus* L.) Venison in Relation to Sex

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Quality of roe deer venison was evaluated based on chemical composition, technological parameters, pH values and colour. Loin (*M. longissimus dorsi*) and leg (*M. gluteus medius*) samples were taken from 14 males and 11 females of roe deer (*Capreolus capreolus* L.). Highly significant differences between samples from the two parts of body were found only in pH (120 h *post mortem*). Highly significant differences between sexes were found in colour values of L* in leg samples at 72 h and loin samples at 120 h, and of a* in loin samples at 72 h. The content of haem pigments ranged from 2.56 to 3.84 mg/g, highly significant differences were found in leg samples. Dry matter content was higher in male venison compared with female venison. Highly significant differences between sexes were found in loin fat content ($p<0.05$) and in total collagen content ($p<0.01$) in leg muscles. The fat content, total and pure proteins and collagen content were higher for males. In both sexes, statistically significantly higher drip loss was found in loin tissues, while cooking loss was higher in leg samples. With respect to sex differences, drip loss of both muscle types was higher in male roe deers, while cooking loss was higher only in loin muscle of females. In our experiment, hardness in excess of 40.00 N was found out in roe deer venison. The highest maximum hardness was found in male leg.

INTRODUCTION

Total venison (deers, wild boars, moufflons, feathered venison, rabbits, *etc*.) production in the Czech Republic exceeds 6000 tonnes per annum. Annual *per capita* venison consumption is estimated at 0.4–0.8 kg, with marked to extreme differences between regions [Czech Statistical Office, 2010a]. As of 31 March 2009, the deer population numbered 318,252 animals [Czech Statistical Office, 2010b], while the total 2008 bag was 127,211 deer [Czech Statistical Office, 2010c], and the total weight of deer venison was 1908.2 tonnes [Czech Statistical Office, 2010d].

Roe deer (*Capreolus capreolus* L.) belongs among the most numerous feral hoofed (big) game species in the Czech Republic. Because of the long hunting season (males: 16 May – 30 Sept., females: 1 Sept. – 31 Dec.), roe deer venison is the most commonly encountered venison in the Czech Republic.

Raw venison is valuable for its high levels of protein and low of fat, which is favourable for nutritional reasons [Konjević, 2008]. It also contains other compounds, such as vitamins and minerals, that are important for the nutritional value [Rywotycki, 2003]. Venison has a fine muscle structure because of the predominance of red muscle fibres over white fibres [Ruiz de Huidobro *et al.*, 2003]. It has low amounts of connective and adipose tissues [Belitz *et al.*, 2009]. Venison has very species-specific aroma and taste characteristics. Venison colour is mainly due to its higher concentrations of haem pigments, most importantly myoglobin and haemoglobin. Colour is a very important criterion for consumers and depends among others on myoglobin concentration, the degree of myoglobin oxidation and on meat structure [Ruiz de Huidobro *et al.*, 2003]. The contents of basic chemicals components in venison depend primarily on the animal's age and sampling place [Rywotycki, 2003]. A general assessment reveals that carcasses of game animals contain only very slight amounts of fat but high levels of proteins. Higher contents of some mineral elements and some taste substances can be traced to differences in diets [Renecker *et al.*, 2001].

The aim of the present study was to characterise selected chemical parameters, technological parameters and texture characteristics, pH values and colour parameters of two muscles, *i.e.* loin (*M. longissimus dorsi*) and leg (*M. gluteus medius*) of roe deer venison and to establish how they are affected by sex.

MATERIALS AND METHODS

Sample preparation

Samples for the study were obtained from roe deer (*Capreolus capreolus* L.), bagged in the Pardubice Region (Czech Republic). Samples were divided into two groups by sex. Fourteen male roe deers harvested in June 2009 and 11 female roe deers harvested in September 2009 were selected from roe

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deer carcasses delivered to a game processing facility. The selection was based on the following criteria: similarity of age (males: 2–3 years, females: 3–5 years), carcass weight after evisceration (males: 12–15 kg, females: 10–14 kg). The harvested animals were shot (no bullet damage to muscles; no carcass contamination due to damage to the digestive tract – bullet damage or incorrect evisceration procedure), eviscerated within 24 h, and passed as wholesome [Regulation (EC) No. 854/2004].

From each skinned roe deer carcass, muscle tissue samples weighing about 300 g were collected from the loin (*M. longissimus dorsi*) and the leg (*M. gluteus medius*). The samples collected were labelled, placed in plastic bags and maintained at a temperature below 7 °C until analysed.

pH value and colour measurement

pH values were measured with a Double Pore needle probe (Hamilton Bonaduz AG, Switzerland) and a 340i WTW pH-meter (WTW, Germany), inserted into the muscle tissue. The colour of raw meat was measured three times by the CIE L*a*b* system using Minolta CM 2600d (Konica Minolta, Japan). Measuring area of 8 mm, illuminant D65 and 10° standard observer were used. The instrument was standardised using a standard white plate. CIE L* – lightness, a* – redness and b* – yellowness were calculated using available software (Spectra Magic 3.61).

Venison colour and pH were measured at 72, 96 and 120 h *post mortem* (time of measurement is indicated by the lower index of pH and colour parameter values). The parameters were measured only after 72 h because it took very long time to obtain samples (transportation of harvested deer, inspection for wholesomeness and safety, and venison sample collection).

Chemical analysis

Samples weighing about 150 g were homogenised for chemical analysis. The following parameters were subsequently determined: amounts of dry matter (103 ± 2°C, 24 h) [International Standard, 1997] and fat analysed on the Soxtec (FOSS Tecator AB, Sweden) with diethylether as the extraction agent. Samples were predried (135 ± 1°C, 3 h) before lipid extraction [Application Sub Note 3127, 2001]. The total protein content was determined by the Kjeldahl method (conversion factor $f_1 = 6.25$). The pure protein content was determined as an amount of organically bound nitrogen after precipitation with hot tannin solution using a Kjeltec 2300 (FOSS Analytical AB, Sweden) semiautomatic analyser following the method recommended by the producer [Application Note 300, 2003]. The content of collagen was computed from the content of hydroxyproline amino acid (conversion factor $f_2 = 8$). Hydroxyproline was determined quantitatively by photometric measurement of absorbance at 550 nm on a GENESYS™6 spectrophotometer (Thermo Electron Corporation, USA). Haem pigment content was determined by the Hornsey method, with the absorbance being measured at 640 nm wavelength [Hornsey, 1956; Izumimoto, 1976].

Instrumental measurement of texture

Meat was cooked in plastic bags separately in a water bath at 72°C, the core temperature of samples was kept at 70°C and held for 60 min. Samples were cooled at room temperature and stored overnight at 4±2°C [Coró *et al.*, 2002]. The cooked samples were tested by Texture profile analysis (TPA) using the Instron Universal Testing Machine, model 5544 (Instron Corporation, England). For TPA, cylinder samples (1 cm high, 1.25 cm in diameter) were compressed twice to 50% of their original height with a compression platen of 36 mm in diameter. Force time curves were recorded at a crosshead speed of 50 mm/min. Hardness (N) defined as the peak force required for the first compression, and cohesiveness defined as the ratio of the positive force area during the second compression to that in the first compression were measured [Szczesniak, 2002].

Drip loss, cooking loss

Drip loss was expressed as a percentage of the initial weight of the meat constituted to exudates. Weighed samples were put into plastic bags and incubated at 4°C for 24 h. Then, the samples were carefully dried and weighed again. Drip loss was determined as the difference between sample weight before and after cold storage [Honikel, 1998].

Cooking loss was analysed as [sample weight before cooking minus sample weight after cooking] ×100/ sample weight before cooking. The samples were cooked in plastic bags separately in a water bath (72°C), the core temperature of samples was held at 70°C for 60 min.

Data analysis

Statistical data analyses were conducted using the STATISTICA 7 CZ statistical program (StatSoft, Czech Republic). Statistical analyses were used in parts of body (*M. longissimus dorsi* and *M. gluteus medius*) and sex. The significance of differences between samples was determined by the analysis of variance (ANOVA) using Tukey's test. The 0.05, 0.01 and 0.001 levels of significance were used.

RESULTS AND DISCUSSION

Evaluation of pH, colour indicators and haem pigments

A distinct feature of wild game meat is a high content of lactic acid produced as a result of anaerobic glycolysis, which contributes to meat acidity. The findings of the cited authors have been confirmed by the present results. In ideal cases, venison pH values measured from 12 to 96 h are between 5.4 and 5.6 [Winkelmayer *et al.*, 2005]. Bittner [2001] reported pH values in the hunting season of roe deer venison between 5.66 (*M. semimembranosus*) and 5.95 (*M. longus coli*). Mojto *et al.*, [1993] reported pH of *M. semimembranosus* at 5.61. Winkelmayer *et al.*, [2004] found on the other hand that *post mortem* pH_{24} values in *M. longissimus* varied according to the season of the year from pH_{24} 5.66 in the spring (which corresponds to the hunting season for roe deer males in the Czech Republic) to pH_{24} 5.58 in the autumn (hunting season for roe deer females).

Development of pH values over time (72 h, 96 h, 120 h) was different in the loin and the leg. Male loin pH (72 h to 96 h) decreased ($p<0.05$). In both male and female leg tissues, statistically higher ($p<0.05$) pH_{96} values were found compared with pH_{72} values in both males and females.

TABLE 1. Roe deer venison – values (mean ± standard deviation) of pH, colour, chemical and technological parameters of *M. longissimus dorsi* and *M. gluteus medius.* Males (n = 14), eviscerated weight 12–15 kg, age 2–3 years, harvested in June 2009.

Parameters			Parts of carcass		*p* value [a, b]
			M. longissimus dorsi (loin)	*M. gluteus medius* (leg)	
			mean±s.d.	mean±s.d.	
pH value		72 h	5.64^{Aa}±0.14	5.52^{Ba}±0.12	N.S.
		96 h	5.51^{Ba}±0.12	5.61^{Aa}±0.10	N.S.
		120 h	5.52^{Ba}±0.09	5.56^{Aa}±0.11	N.S.
Colour	L*	72 h	33.85^{Aa}±2.12	34.93^{Aa}±2.32	N.S.
		96 h	33.59^{Aa}±3.11	35.11^{Aa}±2.64	N.S.
		120 h	33.15^{Aa}±1.58	34.59^{Aa}±2.85	N.S.
	a*	72 h	13.71^{Ab}±1.83	15.31^{Aa}±1.44	$p<0.05$
		96 h	11.46^{Bb}±1.61	13.56^{Ba}±1.64	$p<0.01$
		120 h	12.03^{Ba}±1.97	11.79^{Ca}±2.00	N.S.
	b*	72 h	10.23^{Aa}±1.33	10.92^{Aa}±1.22	N.S.
		96 h	9.73^{Aa}±2.10	10.60^{Aa}±1.55	N.S.
		120 h	7.95^{Ba}±1.14	7.79^{Ba}±1.71	N.S.
	Haem pigments (mg/g)		3.13^{a}±0.70	2.56^{b}±0.46	$p<0.05$
Chemical parameters	Fat (%)		0.58^{b}±0.45	1.27^{a}±0.79	$p<0.01$
	Dry matter (%)		24.95^{a}±0.83	24.67^{a}±0.84	N.S.
	Total protein (%)		22.75^{a}±0.66	21.06^{b}±0.9	$p<0.05$
	Pure protein (%)		20.13^{a}±0.65	19.17^{b}±0.52	$p<0.001$
	Collagen (%)		0.50^{a}±0.18	0.61^{a}±0.14	N.S.
Technological parameters	Drip loss (%)		2.24^{a}±0.52	1.77^{b}±0.51	$p<0.05$
	Cooking loss (%)		27.52^{b}±3.00	37.97^{a}±3.12	$p<0.001$
	Hardness (N)		46.81^{b}±4.62	57.37^{a}±8.66	$p<0.01$
	Cohesiveness (-)		1.28^{a}±0.02	1.27^{a}±0.01	N.S.

[A, B, C] Means in the same column with different letters are significantly different ($p<0.05$). Time of measurement 72 h, 96 h, 120 h.

[a,b] Means in the same row with different letters are significantly different ($p<0.001$, $p<0.01$, $p<0.05$) (*M. longissimus dorsi* v *M. gluteus medius*).

N.S. – No significant differences ($p\geq0.05$).

The glycogen level in leg tissue, which is subject to greater active load than loin tissue, was probably very low. From there on, loin pH developed differently in males and females (Tables 1 and 2). For that reason, pH_{120} of both muscle types in females was higher than in males ($p<0.05$) (Table 3).

Meat colour is important since it is subject to critical appraisal by consumers and is often the basis for product acceptability. Colour is a sensory attribute and its instrumental evaluation must relate to sensory assessment, which may, however, be difficult to perform and control. Visual scoring by a trained panel is the preferred method of subjective analysis and CIE L*a*b* values are appropriate objective measures of colour [Stevenson *et al.*, 1989].

Within individual sex groups, lower L* values were found in the loin muscle. Over the 48 h of monitoring, colour changes were observed in loin muscle of male roe deers. The L* value decreased, *i.e.* its colour got darker. In females, on the other hand, L* values increased over the 48 h (the colour got lighter). Little differences in the values of lightness L* over the 48 h in leg muscle samples of both male and female roe deer were measured (Tables 1 and 2).

At the beginning of monitoring (72 h), redness (a*) values in both sexes were higher in leg muscle (males: $p<0.05$, females: $p<0.001$), with the highest proportion of red pigment having been found in male leg samples (15.31). Time-related changes were apparent (72 h, 96 h, 120 h), with the redness a* value in the leg decreasing in both males and females (Tables 1 and 2). These changes in the loin muscle, however, were not statistically significant.

Yellowness (b*) values were also higher in the leg at the beginning of the monitoring (72 h) in both sex groups. In this parameter, we found different time-dependent (at 72 h, 96 h and 120 h) changes in each of the sex groups. While b* values in males gradually decreased in both muscles and their time-related differences (96 h, 120 h) were statistically significant ($p<0.05$), b* values of female samples initially (72 h, 96 h) were statistically insignificantly, but decreased over the next 48 h (leg: $p<0.05$) (Tables 1 and 2).

The findings show that male roe deer venison was redder compared with female roe deer venison (higher a* values, lower b* values). According to the measured values of L*, meat of does was lighter in colour. The customer expects

TABLE 2. Roe deer venison – values (mean ± standard deviation) of pH, colour, chemical and technological parameters of *M. longissimus dorsi* and *M. gluteus medius.* Females (n = 11), eviscerated weight 10–14 kg, age 3–5 years, harvested in Sept. 2009.

Parameters			Parts of carcass		*p* value [a, b]
			M. longissimus dorsi (loin)	*M. gluteus medius* (leg)	
			mean±s.d.	mean±s.d.	
pH value		72 h	5.55^{Aa}±0.07	5.53^{Ba}±0.04	N.S.
		96 h	5.60^{Aa}±0.09	5.61^{Aa}±0.05	N.S.
		120 h	5.60^{Aa}±0.12	5.67^{Aa}±0.09	N.S.
Colour	L*	72 h	35.11^{Aa}±2.56	35.68^{Aa}±2.49	N.S.
		96 h	35.34^{Aa}±3.57	36.52^{Aa}±2.56	N.S.
		120 h	35.59^{Aa}±3.49	34.84^{Aa}±2.36	N.S.
	a*	72 h	10.67^{Bb}±2.17	13.88^{Aa}±1.32	$p<0.001$
		96 h	12.82^{Aa}±2.47	12.87^{Ba}±2.02	N.S.
		120 h	11.16^{Aa}±1.96	12.23^{Ba}±2.13	N.S.
	b*	72 h	10.58^{Aa}±1.58	10.97^{Ba}±1.58	N.S.
		96 h	11.65^{Aa}±2.69	12.25^{Aa}±1.39	N.S.
		120 h	10.87^{Ba}±2.66	11.18^{Aa}±0.85	N.S.
	Haem pigments (mg/g)		3.84^{a}±1.60	3.36^{a}±0.48	N.S.
Chemical parameters	Fat (%)		0.26^{b}±0.23	0.82^{a}±0.55	$p<0.01$
	Dry matter (%)		24.70^{a}±0.87	24.09^{a}±1.04	N.S.
	Total protein (%)		21.51^{a}±0.88	21.04^{a}±0.26	N.S.
	Pure protein (%)		19.98^{a}±0.85	19.26^{b}±0.65	$p<0.05$
	Collagen (%)		0.60^{b}±0.18	0.94^{a}±0.29	$p<0.01$
Technological parameters	Drip loss (%)		1.61^{a}±0.42	1.24^{b}±0.34	$p<0.05$
	Cooking loss (%)		30.37^{b}±2.69	36.50^{a}±2.38	$p<0.001$
	Hardness (N)		47.21^{a}±9.89	42.15^{a}±11.54	N.S.
	Cohesiveness (-)		1.29^{a}±0.02	1.29^{a}±0.01	N.S.

[A, B, C] Means in the same column with different letters are significantly different ($p<0.05$). Time of measurement 72 h, 96 h, 120 h.

[a,b] Means in the same row with different letters are significantly different ($p<0.001$, $p<0.01$, $p<0.05$) (*M. longissimus dorsi* v *M. gluteus medius*).

N.S. – No significant differences ($p\geq0.05$).

darker and redder colour from the venison, compared to meat of farm animals (beef, pork). From these results it is evident that the consumers choose the venison of male roe deers.

Daszkiewicz *et al.* [2009] determined colour according to the CIE L*a*b* model in red deer (*Cervus elaphus* L.) venison in dependence on sex. They found that males had lower L* and b* values but higher a* values. Purchas *et al.* [2010], on the other hand, found lower L* and b* values in farmed red deer (*Cervus elaphus*) females in dependence on sex. Liu *et al.* [2003] found that beef gets lower L* value, higher a* value and higher b* value with an increasing period of ripening.

The typical darkish red-and-brown colour of venison is generally explained by a higher content of myoglobin [Young & West, 2001], which is necessary because the muscles are subject to a greater load associated with the free movement of animals in the wild [Ruiz de Huidobro *et al.*, 2003]. Venison colour is also influenced by the intensity with which individual carcasses are bled. Also, haem pigment concentrations in individual animals show a high variability caused by blood loss after the animal is shot, and gunshot wound localization also plays a role. According to Hoffman & Wiklund [2006], the rather dark colour of venison is also caused by low amounts of light-coloured connective tissue.

In this investigation, the elevated levels of haem pigment in females in both loin (3.84 mg/g) and leg (3.36 mg/g) muscles were noted. The difference between haem pigment content in female and in male leg muscles was significant ($p<0.01$) (Table 3). Content of haem pigments in the loin muscle was higher in both males and females, and in males, the difference between the loin and the leg haem pigment contents was significant ($p<0.05$) (Tables 1 and 2). Differences between parts of the body could also be caused by bad bleeding of animals. From the nutritional point of view, haem pigments play a considerably important role in supplying the human organism with iron. It has been demonstrated that 10–30% of haem iron gets absorbed in the human organism compared with only 1–5% of nonhaem iron. Roe deer venison may thus serve in human nutrition as a welcomed source of haem Fe, although some other types of venison contain greater quantities of this macroelement, *e.g.* red deer approx. 7.00 mg/g and wild boar approx. 5.50 mg/g [Drew & Seman, 1987]. An increase in haem pigment content is associated

TABLE 3. Comparison between males and females roe deer of *M. longissimus dorsi* and *M. gluteus medius*: *p* values of pH, colour, chemical and technological parameters.

Parameters			Parts of carcass	
			M. longissimus dorsi (loin)	*M. gluteus medius* (leg)
pH value		72 h	N.S.	N.S.
		96 h	N.S.	N.S.
		120 h	$p<0.05$	$p<0.05$
Colour	L*	72 h	N.S.	$p<0.05$
		96 h	N.S.	N.S.
		120 h	$p<0.05$	N.S.
	a*	72 h	$p<0.01$	N.S.
		96 h	N.S.	N.S.
		120 h	N.S.	N.S.
	b*	72 h	N.S.	N.S.
		96 h	N.S.	$p<0.05$
		120 h	$p<0.01$	$p<0.001$
	Haem pigments (mg/g)		N.S.	$p<0.001$
Chemical parameters	Fat (%)		$p<0.05$	N.S.
	Dry matter (%)		N.S.	N.S.
	Total protein (%)		N.S.	N.S.
	Pure protein (%)		N.S.	N.S.
	Collagen (%)		N.S.	$p<0.01$
Technological parameters	Drip loss (%)		$p<0.01$	$p<0.01$
	Cooking loss (%)		$p<0.05$	N.S.
	Hardness (N)		N.S.	$p<0.01$
	Cohesiveness (-)		N.S.	$p<0.001$

N.S. – No significant differences ($p\geq0.05$)

with a decrease in the lightness L* value. This relationship was not corroborated in our experiment in which, contrary to expectation, we found higher levels of haem pigment as well as higher L* values in female compared with male loin and leg muscles (Table 2). The reason may lie in the fact that colour lightness of muscle tissue is closely connected not only with haem pigment levels but also with pH, protein hydration and other parameters (affinity of oxygen, age of animals).

Evaluation of chemical parameters

The protein component (total protein) quality can be judged more accurately by an analytical assay of another two qualitatively different parameters, *i.e.* pure protein and collagen. Chemical composition of venison may vary to some extent because it is influenced by many factors which may be either endogenous (animal species, age, sex, health status) or exogenous (living conditions, food availability and composition, season of the year) [Wiklund *et al.*, 2010]. Winkelmayer *et al.* [2005] point out that venison, in its composition (contents of essential amino acids and vitamins, composition of lipids) and differences in muscle fibre's structure, markedly differs from the composition of meat of farm animals.

The most variable meat component is the fat content. The fat content of meat is affected by a number of factors including species, muscle, gender and age [Wood *et al.*, 2008; Hoffman *et al.*, 2009]. Its quantity is in inverse proportion to the water (or dry matter) content in meat. The presence of fat in venison is important not only from the nutritional but also from the sensory point of view because it contains many aromatic and taste substances. A positive feature of venison is its low cholesterol content [MacRae *et al.*, 2005; Hoffman & Wiklund, 2006].

Roe deer venison ranks among meats with low energy values (440–560 kJ/100 g), which is due to its low muscle fat content. Winkelmayer *et al.* [2004] report the fat content in roe deer *M. longissimus* in dependence on the season of the year ranges from 0.36% (spring) to 1.78% (autumn). According to Zomborszky *et al.* [1996], roe deer venison fat content is 1.7% (*M. semimembranosus* and *M. longissimus*), while Mojto *et al.* [1993] found the fat content in *M. semimembranosus* to be 1.57%. The intramuscular fat content found in both muscles monitored in our experiment in both males and females was also very low. Loin muscle contained less fat (males: 0.58%, females: 0.26%), than the leg (males: 1.27%, females: 0.82%). The fat content in the two muscles also differed within individual sex groups ($p<0.01$) (Tables 1 and 2). The differences ascertained did not, however, affect the dry matter content. Its values in the muscles monitored were practically identical within individual sex groups (Tables 1 and 2). According to Winkelmayer *et al.* [2004], roe deer venison contains on average 25.88% to 27.97% dry matter (*M. longissimus*), similarly Zomborszky *et al.* [1996] noted its dry matter content as 25.7% (*M. semimembranosus*) and 25.2% (*M. longissimus*), whilst Mojto *et al.* [1993] reported 26.52% of dry matter in *M. semimembranosus*.

Compared with meat from farm animals, venison is generally considered a more important source of complete proteins (*i.e.* proteins containing all the essential amino acids), because in addition to myofibrillar proteins, muscle tissues also contain large amounts of sarcoplasmic proteins, with the proportion of connective tissue being low [Taylor *et al.*, 2002; Barnier *et al.*, 1999]. The loin contained more proteins than the leg in both males and females of roe deer. In males, the difference was significant for both types of qualitatively different proteins (total protein: $p<0.05$, pure protein: $p<0.001$) (Table 1). In females, differences were found only in the content of pure proteins ($p<0.05$) (Table 2). Compared with male muscles, female muscles (loin: 0.60%, leg: 0.94%) contained more collagen. In the case of leg muscles, the difference was statistically significant ($p<0.01$) (Table 3). In roe deer *M. longissimus*, Winkelmayer *et al.* [2004] report a total protein content of 22.48% (spring) and 22.77% (autumn). Zomborszky *et al.* [1996] found 23.00% of total proteins in both *M. semimembranosus* and in *M. longissimus*, and Mojto *et al.* [1993] report the content of 23.97% of total proteins in roe deer *M. semimembranosus*. Compared to Winkelmayer *et al.* [2004], who set collagen content in *M. longissimus* at 0.26%–0.38%, the collagen content in this investigation was higher.

Evaluation of technological parameters

Technological parameters are important insofar as they influence further venison processing. In this investigation, high-

er ($p<0.05$) drip loss in loin muscles, and higher cooking loss ($p<0.001$) in leg samples were measured (Tables 1 and 2). With respect to sex differences, drip loss of both muscle types was higher in males roe deer ($p<0.01$), while cooking loss was higher ($p<0.05$) only in the loin muscle of females (Table 3). Cooking losses ascertained in our study (Tables 1 and 2) was markedly lower than those reported by Mojto *et al.* [1993] for *M. semimembranosus* (41.48%).

Meat texture is one of the most important meat parameters for consumers [Denoyelle & Lebihan, 2003]. Meat toughness increases with increasing age of an animal [Sanudo *et al.*, 2004; Hutchison *et al.*, 2010]. Meat tenderness is determined by its structure, condition and chemical composition. To make meat tender, it must be left to age sufficiently to allow *rigor mortis* to loosen up [Shiba *et al.*, 2004].

A comparison among the textural parameters and rheological properties of the muscles from roe deer of different carcass weight showed that old animal muscles were characterised by higher hardness and chewiness than the young ones, whereas cohesiveness was not dependent on carcass weight. Authors comparing muscles of wild boars or different species of farm animals have reported a similar order of hardness for muscles [Žochowska-Kujawska *et al.*, 2007]. In their study, these authors strived to determine the maximum TPA and cohesiveness values in roe deer venison in dependence on carcass weight (10 or 15 kg). They measured TPA (N) and cohesiveness values in dependence on carcass weight for *M. biceps femoris* (31.2–36.35 N and 0.387–0.459), *M. semimembranosus* (27.61–33.60 N and 0.387–0.412) and *M. longissimus* (24.11–28.67 N and 0.341–0.354). Meat from animals of a higher carcasses weight was less tender.

In the present investigation, TPA values of roe deer venison in excess of 40.00 N were measured. The highest TPA value was found in the male leg (57.37 N), which proved to be the most chewy muscle. TPA value was statistically significant ($p<0.01$) between leg and loin of males (Table 1) and the same statistical significance ($p<0.01$) was found between sex in leg muscles (Table 3). In our study, cohesiveness of the two types of muscles was the same within each of the sex groups. Higher cohesiveness values were found in females (Tables 1 and 2).

Conclusions

This investigation showed differences in the monitored parameters of roe deer venison (loin *vs.* leg) both within, and between males and females. This particularly applies to parameters that are related to *post mortem* biochemical processes such as pH and colour parameters of L*, a* and b* that were monitored over a period of time (72 h, 96 h and 120 h) *post mortem*. In relation to sex, lower pH at 120 h after harvesting was found in roe deer males. Both male and female roe deer loin muscle tissue was darker in colour, but less intensely red, even though loin haem pigment levels were higher. The findings show that male roe deer venison was redder compared with female roe deer venison (higher a* values, lower b* values). According to the measured values of L*, meat of does was lighter in colour. Loin muscles were also found to contain more total proteins and pure proteins, and less collagen content and fat. An analysis of technological parameters showed a higher drip loss in the loin than in the leg of both males and females. Cooking loss results were quite the opposite and higher cooking loss values were found in the leg. From the point of view of texture parameters (hardness), the chewier in female roe deer was the leg, in male the loin. Overall, it can be concluded that roe deer venison may, from the point of view of quality parameters monitored, be a delicious food. This is the reason why venison remains a very specific product that is highly a valuable component of a balanced diet of the modern consumer due to its low content of intramuscular fat and a high content of protein.

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