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UTILITY VALUE OF CARCASS OF EUROPEAN DEER (*CERVUS ELAPHUS*) AND ITS MEAT EVALUATION

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Key words: deer, venison, utility value of carcass, meat characteristics, profile of collagen proteins

Analyses of the utility value of deer were conducted on 30 carcasses (female) of does that were dissected into primal cuts and then trimmed to obtain meat. Meat from saddle was determined for: pH, colour, hydratation properties, chemical composition and profile of collagen proteins, and texture profile. Roasted meat from that cut was also subjected to a sensory evaluation. The carcass of deer yielded 74.73% of meat, including 42.38% of meat from leg and 15.23% of meat from saddle. Colour brightness of meat reached 30.92. Meat from the saddle contained 23.13% of protein, 0.63% of collagen proteins, 1.41% of fat, and 0.99% of ash. It was characterised by a high added water holding capacity (59.47%), a low weight loss during roasting (25.95%), and a low content of free water (8.65%). The roasted meat was characterised by a low value of shear force (31.01 N/cm^2), beneficial parameters of texture and desirable attributes of the sensory evaluation.

INTRODUCTION

Currently, exploitation of wild animals is inconsiderable, hence they are not a significant source of food although venison is a healthy and desirable variety of menu. It is obvious that in Europe hunting serves an important function in the management of game populations as well as in maintaining a balance in the existing ecosystems. In addition, it plays some recreational and, to a lesser extent, commercial functions.

Over the last year, the conditions of the population of wild animals, including deer, have been subject to substantial changes (Figure 1).

Deer inhabits the entire area of Poland. The highest number of deers has been reported in the West Pomerania Province (over 20.000 animals). Large populations have also been observed in the provinces of Warmia and Mazury, Wielkopolskie and Pomerania [Anonymous, 2008].

The carcass of deer, likewise that of other animals, is dissected into elements (cuts) so as not to damage the most valuable muscles. During dissection of carcass, consideration is also given to requirements of a recipient, hence various divisions are likely to be applied. Nevertheless, dissection almost always includes the three most valuable cuts, namely saddle, leg and shoulder blade. In the carcass of deer, the leg constitutes over 1/3 of carcass weight. The second cut in terms of weight is the shoulder blade which, together with the leg, constitutes over 50% of carcass weight. However, from the culinary and nutritional points of view, the most valuable cut is the saddle whose contribution in the carcass reaches 13-19%. Apart from the primal cuts, deer carcass may be dissected into: fore (cervix, neck and pectoral part of the half-carcass together with abdominal muscles) or separately into: cervix, neck, ribs and abdominal muscles [Dzierżyńska-Cybulko & Fruziński, 1997; Żmijewski *et al.*, 2007; Deutz & Deutz, 2008].

The tissue composition of the deer carcass is as follows: *ca.* 75% of meat, *ca.* 24.4% of bones, *ca.* 2.1% of tendons and components of connective tissue [Drozd *et al.*, 1996; Dzierżyńska--Cybulko & Fruziński, 1997; Żmijewski *et al.*, 2007].

A typical trait of deer meat is a low value of pH (5.4-6.0) which is maintained for a long period of time *post mortem*. Under refrigeration conditions, this low pH value can be maintained for *ca.* 11 days and then increases very slowly [Smolińska & Klonowski, 1975; Trziszka, 1975; Szmańko, 1979; Smith & Dobson, 1990; Mojto *et al.*, 1993; Dzierżyńska--Cybulko & Fruziński, 1997; Grigor *et al.*, 1997; Wiklund *et al.*, 2001; Pollard *et al.*, 2002].

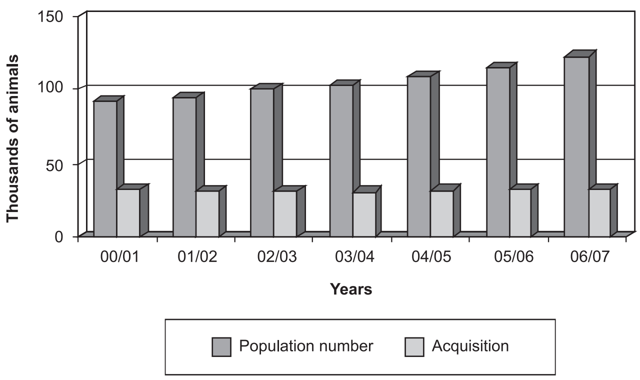

FIGURE 1. Population number and acquisition of deer in Poland [according to the Polish Hunting, Anonymous 2008].

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The chemical composition of game meat differs from the average chemical composition of meat of slaughter animals only to a negligible extent. Differences occurring in the content of major meat constituents as well as in the fatty acid profile of muscle fat, vitamins and microelements are due to divergent living conditions of those animals, migrations in search for feeding grounds, availability of feed, its diversity determined by the season of year and the significant impact of heat period, physical condition of animals, *etc.* [Smolińska, 1975]. The chemical composition of their meat, like that of the meat of slaughter animals, is additionally affected by the age and sex of animal and location of meat in the carcass. A typical trait of deer meat is a low content of fat. According to Uherova *et al.* [1992], it contains 74.80% of water, 22.42% of protein, 2.80% of fat, 1% of carbohydrates, and 1% of mineral substances. Out of the latter, the greatest contribution is reported for potassium and phosphorus as well as for iron whose content is higher as compared to beef [Uherova *et al*., 1992]. According to Mojto *et al.* [1993], the contents of water and mineral substances are similar (74.24% and 0.99%), that of protein is higher (23.44%), and that of fat is lower (1.35%). In addition, those authors emphasize a significant content of iron (3.08 mg/100 g meat). Results of investigations of other authors differ from the above-presented ones only to a small extent [Korzeniowski *et al*., 1975; Smolińska, 1975; Trziszka, 1975; Vigh-Larsen & Jensen, 1994; Drozd *et al*., 1996; Dzierżyńska-Cybulko & Fruziński, 1997; Deutz & Deutz, 2008].

A number of meat characteristics are determined by the content of collagen proteins. In meat of deer they constitute *ca.* 6.5% of total proteins and their content in the muscle tissue of valuable cuts, *i.e.* saddle, leg and shoulder blade, ranges from 1.5 to 1.6% [Smolińska, 1975]. Apart from carcass cut, the content of collagen proteins is differentiated by the sex of deer. According to Dzierzyńska-Cybulko & Fruziński [1997], in meat from the carcass of a buck the content of collagen proteins accounts for *ca.* 2%, whereas in that from the carcass of a doe it accounts for 1.7%, which constitutes respectively 9.6 and 8.0% of total proteins. According to those authors, the highest content of collagen proteins may be found in necks (2.1%) and ribs (1.9%), whereas the lowest in the saddle (1.5%) and leg (1.6%).

In terms of sensory attributes and technological parameters, deer meat is often compared to beef. However, it is characterised by a dark colour as well as specific aroma and taste. Usually such meat originates from animals growing in environmental-friendly conditions, in a natural habitat devoid of effects stemming from commercial breeding [Anonymous, 1997].

The above-presented data on the utility value of carcass and meat of deer were cited from works published over the period of the last 30 years, thus it seems advisable to undertake research to verify that knowledge. This study addresses the evaluation of the utility value of deer carcass as well as a chemical and technological evaluation of meat from the saddle.

MATERIAL AND METHODS

The experimental material for the evaluation of the utility value of deer carcass (female) were 30 carcasses of does with skins, acquired in the Province of Warmia and Mazury. The internal organs were removed at the hunting ground and the carcasses were stored at a temperature ranging from 0°C to -1.5°C. Dressing and dissection into primal cuts according to commercial standards [Company Standard, 1998] were conducted in the production plant of the „LAS" Olsztyn Ltd. company. Each of the cuts was then trimmed to obtain meat. Calculations were made for the contribution of cuts in the carcass and for the content of meat in each cut. Chemical, technological and sensory assessments were conducted on meat from the saddle owing to homogeneity of its *longissimus* muscle and to its exceptional tenderness and juiciness. The saddle was cut out from 10 carcasses 144 h *post mortem*.

The characteristics of raw meat involved determinations of: pH value with a spike electrode directly in the muscle, colour (L*, a*, b*) [Clydesdale, 1978], free water [Hamm, 1972], added water holding capacity [Krełowska-Kułas, 1993], chemical composition [Krełowska-Kułas, 1993] and profile of collagen proteins (total collagen, water-soluble collagen, collagen soluble in 0.5 mol/L CH_3COOH) [Kwiatkowska *et al*., 2002]. Samples of meat from the saddle (*ca.* 500 g) were then subjected to a thermal treatment in hot air (roasting at a temp. of 180°C, to an internal temp. of 75°C), measured for weight loss, texture profile (shear force, TPA test) [Bourne, 1978], profile of collagen proteins [Kwiatkowska *et al*., 2002], and subjected to a sensory evaluation (Table 1), [ISO 4121, 1987]. The results were elaborated statistically by computing mean values and standard error of the mean

TABLE 1. Attributes of the sensory evaluation of meat acc. to a 5-point scale.

Attribute	1	2	3	4	5
Aroma	Significantly perceptible, undesirable aroma, intensive "windy" aroma	Poorly perceptible, undesirable aroma, perceptible "windy" aroma	Poorly perceptible stock-like and herbal aroma, perceptible "windy" aroma	Moderately stock-like, moderately herbal, slightly perceptible "windy" aroma	Desirable, blandly stock-like, herbal, lack of "windy" aroma
Taste	Strongly perceptible extrinsic, non-meat after-tastes	Perceptible extrinsic, non-meat after-tastes	Low desirability, intensively liver-like	Quite desirable, perceptible one of the tastes of the full bouquet	Bouquet, meaty, stock-like, moderately liver-like
Juiciness	Lack of juiciness	Too little juiciness	Sufficient juiciness	Good juiciness	Desirable juiciness
Tenderness	Highly undesirable, fibrous or smeary	Undesirable, fibrous or smeary	Sufficient, hard or slightly smeary	Good, desirable, slightly hard or too tender	Highly desirable, optimally tender
Tenderness of fibres	Thick, separating, difficult to bite open and chew	Medium-thick, separating, requiring long chewing	Sufficiently thin, moderately tender, slightly separating	Quite tender, easy to bite open, non-separating	Tender, fine, easy to bite open, non-separating

(S.E.M.). All calculations were made with the use of Statistica 6.0 pl software.

RESULTS AND DISCUSSION

The mean weight of doe carcass with skin accounted for 68.4 kg, whereas after deskinning, decapitation and cutting off the lower sections of limbs – for 56.2 kg, *i.e.* 82.16% of its initial weight (Table 2). Cuts dissected from the carcass and arranged according to a descending weight were as follows: leg (40.04%), shoulder blade (19.04%), saddle (15.66%), fore (15.12%), and neck (10.14%) (Table 2). The mean weight of the three most valuable cuts, namely leg, shoulder blade and saddle, reached 42.0 kg, which constituted as much as 74.74% of the carcass. The highest mass of meat was obtained from the dissection of leg (17.8 kg) and shoulder blade (8.1 kg), (Table 3). In turn, the mean mass of meat from saddle – the most valuable and desirable cut of deer carcass – reached 6.4 kg. It may be speculated that carcass of those animals yields 42 kg of meat, including 6.4 kg of delicatessen meat (saddle), 25.9 kg of culinary meat (meat from leg and shoulder blade) and 9.7 kg of culinary trimmings (from fore and neck), (Table 3). Worthy of notice is the high contribution of meat from leg in the mass of meat from the whole carcass that accounted for over 42%. As compared to meat yields from cuts of deer carcass reported by Dzierżyńska-Cybulko & Fruziński [1997], in the carcass of the animals under study the content of meat was higher by 1.3%. These authors provide the same order of cuts according to a descending weight, yet the content of meat in particular cuts demonstrated in their work is lower. A similarly lower contribution of meat in cuts of deer carcass was reported by Drozd *et al*. [1996], whereas a very similar one was reported by Trziszka [1975].

TABLE 2. Utility value of deer carcass (mean ±S.E.M., n=30).

Specification	Weight (kg)	Content (%)
Carcass with skin	68.4±2.11	100.00
Head	3.3±0.11	4.82±0.08
Skin	6.3±0.24	9.21±0.34
Limbs	2.6±0.07	3.80±0.08
Carcass	56.2±1,87	82.16±0.69
Carcass cuts	Weight (kg)	Contribution in carcass (%)
Leg	22.5±0.76	40.04±0.43
Shoulder blade	10.7±0.34	19.04±0.18
Saddle	8.8±0.37	15.66±0.27
Fore	8.5±0.28	15.12±0.14
Neck	5.7±0.22	10.14±0.13

TABLE 3. Content of meat in cuts and carcass of deer (mean ±S.E.M., n=30).

Cut	Mass of meat in cut (kg)	Contribution of mean in cut (%)	Contribution of meat in the mass of meat from carcass (%)
Leg	17.8±0.87	79.11±0.92	42.38±0.71
Shoulder blade	8.1±0.47	75.70±0.82	19.28±0.59
Saddle	6.4±0.32	72.72±0.79	15.23±0.55
Fore	5.9±0.22	69.41±0.71	14.05±0.44
Neck	3.8±0.16	66.67±1.07	9.05±0.31
Carcass	42.0±1.34	74.73±1.29	100

The evaluated meat from deer saddle displayed characteristics typical of game meat. One of those characteristics is the value of pH. Mean pH value in meat from deer saddle reached 5.55 (Table 4). The result obtained is typical of venison [Smolińska & Klonowski, 1975; Trziszka, 1975; Szmańko, 1979; Mojto *et al*., 1993; Dzierżyńska-Cybulko & Fruziński, 1997; Ishida *et al*., 1991; Wiklund *et al*., 2001], and confirms that meat of does is characterised by lower pH than that of the bucks [Smith & Dobson, 1990; Vigh-Larsen & Jensen, 1994].

The colour of meat of wild animals is usually darker and more intensive compared to the slaughter animals. The brightness of the meat examined accounted for 30.92 units, thus confirming the commonly known dark colour of venison (Table 4) [Rede *et al*., 1986; Dzierżyńska-Cybulko & Fruziński, 1997]. The result obtained is similar to data characterising meat of 5-6-year-old does from farm breeding [Stevenson *et al*., 1992] and to data reported by Duranti *et al*. [1994], as well as lower as compared to the meat of young farm animals in the case of which the L* values ranges from 32 to 34 [Stevenson *et al*., 1992; Woodford *et al*., 1996; Vergara *et al*., 2003; Volpelli *et al*., 2003]. The contribution of a* component in meat colour reached 10.72 (Table 4). Since its contribution in the colour of deer meat may be diversified as affected by age, sex, type of muscle, feeding, acquisition technique, transportation, heating period, electrical stimulation of carcasses, *etc.*, it may fluctuate between 13 and 19 units [Stevenson *et al*., 1992], or 15 and 17 units [Woodford *et al*., 1996; Pollard *et al*., 2002; Vergara *et al*., 2003]. The value determined

TABLE 4. Characteristics of meat from deer carcass (mean ±S.E.M., n=10).

Parameter	Value
pH	5.55±0.02
Brightness L*	30.92±0.17
Redness a*	10.72±0.14
Yellowness b*	21.74±0.22
Total water (%)	74.46±0.42
Free water –% of total water	8.65±0.77
Water holding capacity (%)	59.47±4.44
Weight loss – roasting (%)	25.95±0.48
Shear force (N/cm^2)	31.01±1.57
Hardness I (N/cm^2)	34.93±1.23
Hardness II (N/cm^2)	40.45±1.42
Gumminess (N/cm^2)	22.27±0.93
Chewiness (J/cm^4)	12.34±0.75
Springiness (mm/cm^2)	0.53±0.01
Cohesiveness	0.55±0.01

in the current study, being lower than the reference data, confirms the exceptionality of meat from saddle as compared to meat from the other cuts.

The chemical composition of meat from deer saddle also did not differ from that reported in literature [Korzeniowski *et al*., 1975; Ishida *et al*., 1991; Mojto *et al*., 1993; Duranti *et al*., 1994; Vigh-Larsen & Jensen, 1994; Dzierżyńska-Cybulko & Fruziński, 1997; Ishizuka *et al*., 2001; Deutz & Deutz, 2008].

In the evaluated meat, the content of water reached 74.46%, thus was typical of venison (Table 4). Unbound water or that from the zone being the most remote from collagen proteins constitute free water. Its content in the meat analysed constituted 8.65% of the total water mass and was considerably lower than the values provided by Trziszka [1975] for the same muscle as well as by Smolińska & Klonowski [1975] for the *semimembranosus* muscle. The meat from deer saddle was additionally characterised by good added water holding capacity (59.47%). A worse value of that parameter was demonstrated by Duranti *et al*. [1994] for the *longissimus* muscle (46.52%) and even worse (31.57%) by Szmańko [1979] for the meat from leg. The content of water in meat of the game is negligibly higher than in the meat of slaughter animals, which is due to a lower content of intramuscular fat in the game meat. The content of fat in the examined raw meat reached 1.41% (Figure 2). The nutritional value of meat is also determined by the content of mineral compounds, generally determined as the content of ash. Minerals are characterised by a high biological activity. Even a small quantity supplied to a body catalyzes the formation of new compounds indispensable for health and the general well-being of an organism. Both the content and composition of mineral salts in wild animals are influenced by the mode of feeding. The major source of feed to those animals are plants rich in vitamins and mineral salts. In the evaluated meat from the saddle, the total content of ash reached 0.99% (Figure 2).

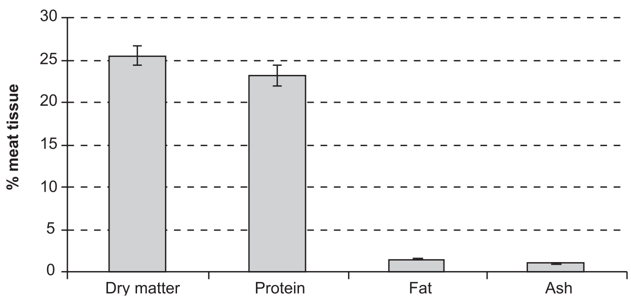

FIGURE 2. Chemical composition of meat from deer saddle (mean ±S.E.M., n=10).

Due to a significant impact on the nutritional value of meat, one of its major constituents is protein. Its content in the analysed meat from the saddle reached 23.13%, thus confirming the fact that meat of the game is characterised by a relatively high content of protein (Figure 2). Its content may vary between *ca.* 19% to even 25% [Korzeniowski *et al*., 1975; Trziszka, 1975; Ishida *et al*., 1991; Uherova *et al*., 1992; Mojto *et al*., 1993; Vigh-Larsen & Jensen, 1994; Drozd *et al*., 1996; Dzierżyńska-Cybulko & Fruziński, 1997; Ishizuka *et al*., 2001; Deutz & Deutz, 2008].

Proteins delivered to a body differ in their nutritional value. Proteins of the muscle tissue and connective tissue are characterised by a different composition and contents of exogenous amino acids. Collagen is a protein that decreases the nutritional value because it lacks some important amino acids, such as tryptophan and tyrosine and sulfuric amino acids. Therefore, the content of protein determined in meat should include the content of collagen proteins. The mean content of collagen in the analysed meat from the saddle reached 0.63%, which constituted 2.72% of total proteins (Table 5). The values obtained in the current study are lower than those reported by Smolińska & Klonowski [1975] as well as by Dzierżyńska-Cybulko & Fruziński [1997].

The mean content of collagen proteins in the raw meat from the saddle reached 633.18 mg/100 g meat. Their profile had the highest content of insoluble proteins (482.77 mg/100 g), and the lowest water-soluble proteins (57.08 mg/100 g), (Table 5). It is assumed that the contribution of collagen proteins below 5% of the total protein mass is a typical characteristic of meat recognized as low-collagen raw material, which is usually defined as tender with a delicate structure [Purslow, 2005]. In turn, the contents of soluble and insoluble collagen in the total content of connective tissue enable determining whether meat originates from older or younger animals, because the former have a higher content of insoluble collagen, whereas the latter have a higher content of collagen occurring in the soluble form [Purslow, 2005]. The results obtained indicate that the meat analysed originated from young, but mature animals. The thermal treatment was found to affect a change in both the content and profile of collagen proteins (Table 5). The roasted meat displayed a higher content of those proteins (789.87 mg/100 g), caused by a thermal drip which is always greater in the low-collagen raw materials. The roasted meat had an increasing content of collagen compounds soluble in water and in 0.5 mol/L CH_3COOH which together consti-

TABLE 5. Collagen profile of meat from deer saddle (mean ±S.E.M., n=10).

Parameter	Raw meat		Thermally-treated meat	
	(mg/100 g)	(%)	(mg/100 g)	(%)
Total collagen	633.18±27.24	100.00	789.87±53.99	100.00
Collagen –% of total protein		2.72±0.18		
Water-soluble collagen	57.08±15.15	9.01±0.26	248.06±39.13	31.40±2.03
Collagen soluble in 0.5 mol/L CH_3COOH	93.33±38.05	14.73±0.32	181.75±58.50	23.01±1.82
Total soluble collagen	150.41±21.61	23.74±0.92	429.81±43.21	54.41±2.86
Collagen insoluble in 0.5 mol/L CH_3COOH	482.77±36.54	76.26±3.48	360.08±31.42	45.58±2.28

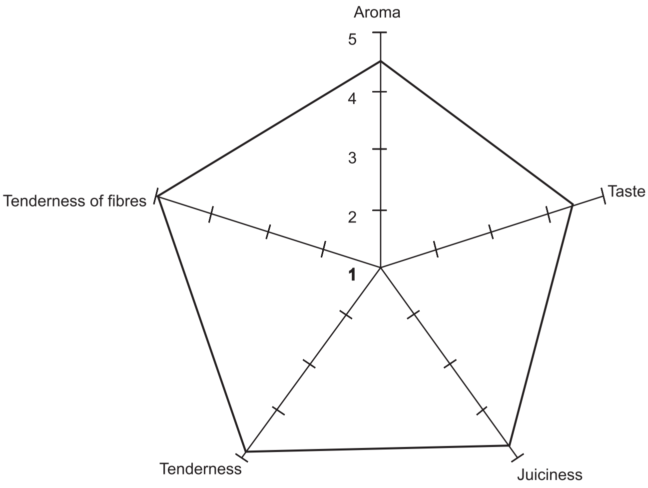

FIGURE 3. Sensory evaluation of meat from deer saddle (n=10).

tuted 54.41%, as well as by a decreasing content of insoluble collagen. Those changes point to a considerable destruction of collagen fibres and to progressive hydrolysis of tropocollagen molecules.

The low content of collagen proteins and their beneficial profile in the roasted meat affected the results of the instrumental and sensory evaluation of its texture and tenderness (Table 4, Figure 3). Analyses demonstrated a low value of shear force accounting for 31.01 N/cm^2, whereas low and similar values of hardness I (34.93 N/cm^2) and II (40.45 N/cm^2) point to thin and delicate fibres. Also the remaining parameters of TPA test indicate a tender structure of studied meat.

A similar value of the shear force of the *longissimus* muscle was reported by Wiklund *et al.* [2001] for meat after 6 weeks of chill storage. According to Mojto *et al.* [1993], the shear force of the *semimembranosus* muscle accounted for *ca.* 50 N/cm^2, thus is substantially higher. Likewise, the higher value the shear force in meat subjected to thermal treatment (in water) was demonstrated by Stevenson *et al.* [1992], Duranti *et al.* [1994] as well as Vigh-Larsen & Jansen [1994].

The thermal treatment of meat from deer saddle caused a loss of weight that reached *ca.* 26% (Table 4). Despite a relatively low content of collagen proteins, the value obtained is lower than losses demonstrated for venison by some authors [Trziszka, 1975; Mojto *et al*., 1993]. Some studies on that subject refer to meat subjected to a long-term thermal treatment which results in greater weight losses and a higher value of shear force. However, there are also some studies reporting losses similar to those demonstrated in the current study [Stevenson *et al*., 1992; Duranti *et al*., 1994].

The meat from deer saddle subjected to a sensory evaluation obtained the following score for particular attributes: aroma – 4.50, taste – 4.46, juiciness – 4.73, tenderness – 4.86 and tenderness of fibres – 4.95 (Figure 3). The roasted meat from deer saddle was demonstrated to be characterised by a very desirable tenderness, delicate, perceptible and easy to bite open texture and was juicy. In addition, it was shown to possess an exceptionally interesting and desirable taste bouquet, including among others: stock-like taste, slightly liver-like, herbal being typical of wild animals, different than that of the slaughter animals. Its aroma was slightly herbal, slightly "windy", slightly stock-like and highly desirable.

CONCLUSIONS

The study demonstrated that the carcass of deer enables obtaining *ca.* 75% meat on average, including *ca*. 42% of meat from leg and *ca*. 15% of meat from saddle. The meat from deer saddle is characterised by colour parameters not always typical of the meat of the *Cervidae,* its brightness accounts for 30.92 units, and the contribution of red component in the color is 10.72. A typical trait of meat from the saddle is a high content of total protein (with a low contribution of collagen proteins), a low content of fat and a low value of pH. For these reasons, the saddle of deer may be acknowledged as a raw material with an exceptionally high nutritional value. Despite a low content of proteins, the analysed meat is characterised by a high added water holding capacity (59.47%), a small weight loss during thermal treatment (25.95%), and a low content of free water (8.65%). The low content of collagen proteins and their beneficial profile in the roasted meat affect results of the instrumental and sensory evaluation of its texture and tenderness. It is manifested in a low shear force reaching 31.01 N/cm^2, beneficial parameters of texture and desirable attributes of the sensory assessment. The low content of fat does not contribute to deterioration of meat juiciness.

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