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Original article

Amino acids content and basic chemical composition of roe deer (*Capreolus capreolus* L.) meat

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Abstract

The aim of this study was to determine the chemical composition of roe deer meat considering the animals' sex and age and to estimate the content of amino acids in the meat from two selected groups of the animals, i.e. 2-3-year-old males and females. A further goal was to assess the biological value of proteins as compared to the FAO standard. The study has revealed that in proteins from the roe deer muscle tissue the content of exogenous amino acids (in g/100g) is higher by 20-30% on average comparing to the level of amino acids, in the FAO/WHO (1973) standard protein. Among the endogenous amino acids, the highest (in g/100 g of protein) and the lowest concentrations were found for glutamic acid and proline, respectively. The research has also shown that roe deer meat possesses a high content of protein and a relatively low content of fat.

Key words: meat, exogenous and endogenous amino acids, protein, fat, dry matter

Introduction

Culinary and rheological values of animal material are mainly affected by the chemical composition of muscular, connective and adipose tissue. The basic components of meat include water, proteins, intramuscular fat, minerals and vitamins. Numerous studies have indicated that their respective ratio is species-, age- and sex-dependent, and that it is also dependent on the animal's adiposity, as well as the part of the body from which the carcass was extracted (Berndsen and Pligt 2004, Warren et al. 2008).

Meat is a primary source of proteins of high biological value. The proteins' nutritional value varies depending on their amino acid composition, in particular on their exo- and endogenous amino acids ratio (Jansen 1993).

The aim of this study was to determine the chemical composition of roe deer meat considering on the animals' sex and age, and to estimate the content of amino acids in the meat from two selected groups of animals, i.e. 2-3-year-old males and females. A further goal was to assess the biological value of proteins as compared to the FAO standard.

Materials and Methods

The investigations involved 67 roe deer (*Capreolus capreolus* L.), coming from a Polish region dominated

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by food, chemical, electromechanical, timber and paper industries. Agricultural lands constitute 65% of the area. The research animals were hunted in their natural environment. The material was obtained during two hunting seasons, 2005/2006 and 2006/2007. The bucks were shot between 11 May and 30 September, while the does and fawns – from the beginning of October to mid-January. The bucks hunting method differed depending on the season. In spring, the best results were obtained while hunting from a well-situated high stand, while in summer the bucks were lured by imitating the voice of a doe in heat. In the autumn and winter seasons, while hunting does and fawns, a high stand and stalking method was applied.

The animals were shot by individual hunters and divided afterwards into age and sex groups: group I – 2 to 3-year-old males (n=12), II – 4 to 5-year-old males (n=10), III – 6 to 7-year-old males (n=10), IV – 2 to 3-year-old females (n=14), V- 4 to 5-year-old females (n=12) and VI – 6 to 7-month-old females (n=9). The age of the animals was determined on the basis of their dentition, i.e. on the basis of the extent to which some parts of teeth were developed or worn.

After shooting the animals, the samples were collected from the longissimus muscle from the back (from the section corresponding to the first three lumbar vertebra) and placed in sterile, tightly closed Ziploc bags in cooling conditions (4°C), transported as quickly as possible (in less than 5 hours) to the laboratory, where the analyses were performed. The muscle samples were divided into pieces of specified mass and prepared adequately for the tests (freeze-dried, cooled). In the further assessment process, the specifications concerning the planned analyses (i.e. following the steps stipulated by the given norms) were taken into consideration. Due to the fact that the samples derived from wild animals and were collected immediately after shooting, the study did not cover the assessment of the exsanguination rate of the carcasses.

The evaluation of proteins content was performed using the Kjeldahl method (A.O.A.C. 2000), conforming to PN-ISO 14444:2000. Fat content was determined using the Soxhlet method, conforming to PN-ISO 6492:2005. The dry matter content was determined using PN-ISO 6496:2002 (ISO 6496:1999 E). These parameters were measured in samples from the lumbar part of the longissimus muscle.

Amino acids were determined only in the samples from the two most numerous groups of animals, i.e. in the meat of 2-3-year-old bucks and 2-3-year-old does, taking into account 8 individuals from each group. The samples were freeze-dried in Lyovac GT2 lyophilizing cabinet from FinnAqua, and afterwards, the amino acid profile was determined.

Sulfur amino acids, i.e. cystine and methionine were estimated in the form of cysteic acid and methionine sulfone, after the samples' oxidation with performic acid ($HCOOH+H_2O_2$). The acid was then vaporized and the samples were subjected to hydrolysis in 6 M hydrochloric acid (HCl) at 110°C for 24 hours in nitrogen atmosphere, in glass vials (Scram et al. 1954, Moore 1963).

Tryptophan was determined using the colorimetric method with p-dimethylaminobenzoic aldehyde, conforming to the Polish norm PN-77 R-64820 (category XV 49).

Hydrolysis of the samples was performed in 1.07 [mol/dm^3] solution of barium hydroxide at 110°C for 16 hours in nitrogen atmosphere (Howe et al. 1972).

The remaining amino acids were determined using Biochrom 20 plus automatic amino acid analyzer and reagents from Biochrom Ltd Cambridge England.

For an amino acid standard, Amino Acid Standard Solution AAS-18, Amino Acid Standards For Protein Hydrolysates Containing Norleucine A 2908, as well as L-methionine sulfone, L-cysteic acid and L-norleucine from Sigma were used.

Hydrolysis of proteins from the examined samples was performed in glass vials in nitrogen atmosphere, in 6 M HCl at 110°C for 24 hours.

Furthermore, the biological value of the proteins found in the muscle tissue was calculated using Mitchell and Block's limiting essential amino acid CS (Chemical Score) from amino acid composition. This factor was calculated for exogenous amino acids from quantitative ratio of each of them in the examined protein to their [mg/g] content in standard protein. For the standard, the amino acid composition of proteins formulated by FAO in 1973 (FAO/WHO Report) was used.

The results obtained were statistically analyzed with Statistica 8.0 (StatSoft, USA). The results of some measurements did not meet the assumption of normal distribution (which was established using the Shapiro-Wilk test) and the assumption of homogeneity of variance, required while applying parametric tests. Therefore, in order to investigate the statistically significant differences among the groups, the Kruskal-Wallis non-parametric test (non-parametric ANOVA) was applied, and for tracing the relations between the selected parameters Spearman correlation was followed. In the cases of parameters which fulfilled the assumptions of normal distribution and homogeneity of variance, parametric ANOVA (analysis of variance) was applied, while Pearson's correlation was used for investigating the relations between

the parameters. The results obtained were statistically analyzed using arithmetic mean ($\bar{x}$) and standard deviation (s). The use and handling of animals for this experiment was approved by the Local Ethical Committee (no. 4/2006).

Results

The results of determining the basic composition of roe deer meat are presented in Table 1. The highest percentage content of protein was found in 2-3-year-old females and 2-3-year-old males, while the lowest one in fawns. However, no statistically significant difference for this parameter was noted. Therefore, the experiments have revealed that roe deer meat is abundant in protein. The present study has also revealed no age- or sex-dependent differences in protein content. The lowest fat content was found in 4-5-year-old bucks and the highest one in 2-3-year-old does. Statistically significant differences ($p \leq 0.05$) for these parameters were noted between 2-3-year-old and 4-5-year-old bucks, 2-3-year-old and 6-7-year-old bucks, as well as 2-3-year-old does, 2-3-year-old bucks and fawns and between 4-5-year-old bucks and 2-3-year-old does. The muscle was also examined in regard to its dry matter content, and for this parameter, statistically significant differences were found between 2-3-year-old bucks and 6-7-year-old bucks and fawns, as well as between 6-7-year-old bucks and 2-3-year-old does. The lowest rate of this parameter was observed in the muscle of 6-7-year-old bucks and the highest one in the muscle of 2-3-year-old does. The concentrations of endogenous amino acids found in the experimental groups, i.e. 2-3-year-old bucks and 2-3-year-old does, are presented in Table 2. No statistically significant difference was observed between males and females in regard to this parameter. The highest ratio (in g/100 g of protein) was found for glutamic acid.

Table 2. Endogenous amino acids content in roe deer meat [g/100 g].

Parameter [g/100g]		Experimental group	
		I	IV
Age of the animals		2÷3-year-old ♂	2÷3-year-old ♀
Total proteins [%]	$\bar{x}$	83.12	80.77
	s	1.02	1.10
Asp	$\bar{x}$	9.21	9.31
	s	0.06	0.18
Ser	$\bar{x}$	3.86	3.94
	s	0.05	0.15
Glu	$\bar{x}$	13.82	13.94
	s	0.17	0.24
Pro	$\bar{x}$	3.71	3.75
	s	0.06	0.13
Gly	$\bar{x}$	4.11	4.16
	s	0.05	0.07
Ala	$\bar{x}$	5.50	5.46
	s	0.04	0.08
Total	Σ	40.21	40.56

The lowest ratio was observed in case of proline, which was present in the meat of 2-3-year-old bucks, a quantity similar to that observed in 2-3-year-old does, i.e. 3.75 [g/100 g].

The content of exogenous amino acids in the meat of 2-3-year-old bucks and 2-3-year-old does is presented in Table 3. Despite the similar values within the experimental groups, some statistically significant differences between the content of these compounds were found. The highest ratio (in g/100 g of protein) was observed in case of leucine in the first and in the fourth group. For this amino acid statistically significant differences were observed depending on the animals' sex ($p \leq 0.05$).

Table 1. Chemical composition of roe deer meat [%].

Parameter [%]		Experimental groups					
		I	II	III	IV	V	VI
Age of the animals		2÷3-year-old ♂	4÷5-year-old ♂	6÷7-year-old ♂	2÷3-year-old ♀	4÷5-year-old ♀	6÷7 month-old ♀
Dry matter	$\bar{x}$	25.53^{a}	25.99	24.80^{b}	26.77^{ac}	25.56	24.98^{bc}
	s	0.77	0.59	0.53	1.06	1.56	1.33
Protein	$\bar{x}$	24.02	23.87	23.81	24.06	23.63	23.12
	s	0.68	0.29	0.82	0.66	1.01	1.30
Fat	$\bar{x}$	0.43^{a}	0.31^{bd}	0.40^{bc}	0.72^{e}	0.58	0.37^{d}
	s	0.12	0.08	0.24	0.24	0.32	0.11
Nitrogen	$\bar{x}$	3.84	3.82	3.81	3.85	3.78	3.70
	s	0.11	0.05	0.13	0.11	0.16	0.21

The values marked with different letters in the same row vary statistically ($p \leq 0.05$).

Table 3. Exogenous amino acids content in roe deer meat [g/100 g].

Parameter [g/100g]		Experimental group and amino acids content [g/100 g]	
		I	IV
Age of the animals		2÷3-year-old ♂	2÷3-year-old ♀
Arg*	$\bar{x}$	6.62[a]	6.77[b]
	s	0.10	0.10
His*	$\bar{x}$	3.50[a]	3.87[b]
	s	0.29	0.11
Ile	$\bar{x}$	4.96[a]	5.09[b]
	s	0.04	0.12
Leu	$\bar{x}$	8.61[a]	8.80[b]
	s	0.06	0.07
Lys	$\bar{x}$	8.24[a]	8.69[b]
	s	0.25	0.13
Met+Cys	$\bar{x}$	3.77[a]	3.9[b]
	s	0.04	0.13
Phe+Trp	$\bar{x}$	7.41[a]	7.78[b]
	s	0.19	0.26
Thr	$\bar{x}$	4.53	4.59
	s	0.04	0.06
Trp	$\bar{x}$	1.22[a]	1.27[b]
	s	0.01	0.03
Val	$\bar{x}$	5.45	5.59
	s	0.18	0.09
Total	Σ	54.31	56.35
CS (Met)		**1.08**	**1.11**

The values marked with different letters in the same row vary statistically ($p \leq 0.05$).
* – conditionally essential amino acids

The lowest ratio was found in case of tryptophan in the meat of 2-3-year-old bucks and in the meat of 2-3-year-old does. The differences for this parameter were statistically significant ($p \leq 0.05$).

Statistically significant differences within the groups were also shown among other amino acids, with the exception of threonine and valine.

The limiting amino acid (CS) was methionine, which in the protein examined, compared as to the standard protein, was present in the smallest amount (from 1.08 in the first group to 1.11 in the fourth group). As it was mentioned before, CS is the lowest ratio, calculated for all exogenous amino acids of the amino acids content in the protein examined, as compared to the amino acids content in standard protein (in mg/g of protein).

Discussion

Meat is an important source of protein and other valuable nutritious components indispensable for the organism's proper functioning. As little as 100 g of skim boiled meat provides half of the necessary amount of protein in a daily diet. The nutritional value of proteins depends on the proper ratio of total exogenous amino acids to total endogenous acids. In the proteins from roe deer muscle tissue the content of exogenous amino acids (in g/100 g) was higher by 20-30% on average as compared to the level of amino acids in the FAO/WHO (1973) standard protein. Moreover, their total amount in the meat of the animals examined was between 54.31 and 56.35 [g/100 g], while in standard protein, this amount was approximately 36 [g/100 g]. For comparison, the meat of 2-3-year-old fallow deer showed slightly lower content of protein, i.e. between 21.67% (Volpelli 2003) and 23.1%, while for red deer, this rate was from 19.9 to 24.7% (Dzierżyńska-Cybulko and Fruziński 1997). It is also noteworthy that protein content in venison is usually higher than in the meat from farm animals. This thesis is supported by numerous publications concerning the chemical composition of beef or pork, in which the protein ratio was between 18% and 23% for the porcine longissimus muscle (Szalata et al. 1999, Kapelański et al. 2002) and about 21-22% for muscles of cattle (Daszkiewicz and Wajda 2002). The present study has revealed no age- or sex-dependent differences in protein content, however, the research by Pieniak-Lendzion (2002) on the goat longissimus lumborum muscle showed a slight, but statistically important decrease in the total protein content along with the animals' aging.

Taking into consideration its dietetic value, such as low content of the intramuscular fat (stemming from the animals' behaviour), venison can be acknowledged as a valuable element of diet. A support for this thesis can be provided by the results obtained in our research which has revealed that roe deer meat contains less fat than the meat of other chase or farm animals. For reference, fallow deer meat contained from 0.59 to 0.75% of fat (Volpelli 2003). Moreover, in older animals this value was even higher (Giorgetti et al. 1996). The present results confirm this only in case of 4-5 and 6-7-year-old bucks, in which the fat content in the muscle increases along with the animals' age.

The analysis of the basic chemical composition of roe deer meat suggests that it is highly beneficial for several reasons. The kind of chemical compounds and their respective ratio affects meat's digestibility, nutritional value, as well as its technological applicability (Wajda 1998).

The concentration of exogenous amino acids in the roe deer longissimus lumborum muscle showed statistically significant differences within the examined groups of animals. Results concerning the content and total amount of exogenous amino acids similar to those presented for roe deer meat were obtained by Jansen (1993) on rabbit meat. Jansen (1993) faund that their level was higher by about 2% as compared to the meat of other animals (cattle, poultry and pigs). The results of Webb et al. (2005), obtained on homologous muscles of goats, showed values in the exo- and endogenous amino acids profile similar to those found in roe deer meat. It is, however, noteworthy that roe deer meat contains slightly more tryptophan and sulphur amino acids than the goat meat, in which their content ranges from 0.77 and 1.0 [g/100 g] in case of tryptophan, and about 3.1 [g/100 g] in case of cysteine-methionine complex. Moreover, in females the content of all marked amino acids was slightly higher than in males (Webb et al. 2005). Such a dependency was also observed in the present study. Comparing the present results with those obtained in the meat of farm animals, it can be clearly stated that roe deer meat is a perfect source of valuable protein and that it covers the daily demand of exogenous amino acids more effectively.

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