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An evaluation of the protein quality of some macedonian edible Boletaceae mushrooms

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Abstract

The nutritional quality of mushroom protein varies and is strongly affected by the relative proportion of each amino acid. Thus, the purpose of this study was to estimate the concentration of the amino acids present in mushroom proteins in order to evaluate the protein nutritional value. In this investigation fifteen field-collected mushroom samples of the Boletaceae family from various parts of Macedonia were included. After acid hydrolysis and pre-column derivatisation with phenyl isothiocyanate (PITC) determination of seventeen amino acids was carried out by the HPLC method. Tryptophan was determined spectophotometrically in the alkaline hydrolysates. The dietary protein quality of the investigated mushrooms was evaluated by comparison of the essential amino acid content with the reference FAO/WHO pattern. Essential amino acids made up 47-75 % of all determined amino acids depending on the origin and the species of the fruit body. Lysine was the most often found limiting amino acid in the investigated mushrooms samples. The nutritional value of proteins calculated by biological value, protein ratio, chemical score and essential amino acid index was very high in the majority of mushrooms studied. The biological value of the mushroom protein varied from 51.3 to 78.9 %. Protein amino acids accounted for about 66.7 % of the total nitrogen, suggesting that a practical nitrogen to protein conversion factor for this Macedonian edible Boletaceae mushroom may be considered to be about 4.17 on average.

Key words: Boletaceae, mushrooms, protein quality, amino acid content, HPLC

Introduction

Proteins are essential components of the diet needed for the survival of animals and humans. Proteins' basic function in nutrition is to supply adequate amounts of necessry amino acids. The protein quality, an important part of the nutritional or nutritive value of a food, depends on its amino acid content. Most literature data consider edible mushrooms as a source of good quality proteins (1,2). In Macedonia many kinds of wild Boletaceae mushrooms have acquired popularity as common food in addition to their usual use as condiments. No information is available so far on the protein content and quality of a great number of the wide-spread wild edible species in question. In order to establish the protein quality of Macedonian edible Boletaceae mushrooms, it is desirable to determine their protein content as well as to estimate the concentration of the amino acids present in their proteins. In this way this report will provide information on these mushrooms from Macedonia, distinguished for their protein content and great nutritional value.

Experimental

Samples

The present study comprised fifteen species of Macedonian edible mushrooms from the Boletaceae family (of the *Boletus*, *Suillus* and *Leccinium* genera). All the samples were field collected in different areas of Macedonian in the course of 1997/99. Identification (3) of the samples was confirmed by Dr. M. Karadelev and voucher specimens were deposited at the Macedonian collection of mushrooms which belongs to the Institute of Biology at the Faculty of Natural Sciences in Skopje. After collecting, dry matter content was determined immediately by drying at 105 ^{0}C and the remaining part was stabilized, dried and milled to pass through a 0.2 mm screen. All

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the samples represent the whole mushrooms and were analyzed in triplicate for the determinations.

Protein determination

The level of total nitrogen was determined by the micro -Kjeldahl method (960.52, AOAC, 16th edition, 1995)(4), and percent protein was calculated as % N x 6.25. By substraction of the water released during the amino acid condensation from the protein from the total sum, the net (pure) protein content was calculated (5).

Amino acid analysis

Seventeen amino acids were determined by HPLC after acid hydrolysis with constant boiling hydrochloric acid and pre-column derivatisation with phenyl isothiocyanate (PITC) (6,7). A Perkin Elmer (USA) HPLC equipped with Binary LC Pump (model 250), UV diode array detector (model 235) set at 254 nm and Waters (USA) Pico-Tag column was used. A Mistral thermostated oven (type 880, Spark Holland, The Netherlands) was used for maintaining the constant column temperature at 38±1^{0}C. The amino acid content was calculated upon the standard curve of amino acid standard H (Pierce I, USA). Amino acid standard H was prepared and derivatised simultaneously with the samples.

The mobile phase consisted of aqueous buffer (0.14 mol L^{-1} sodium acetate, 0.5 mL L-1 triethylamine and titrated to pH 6.4 with glacial acetic acid) (Solvent A) and 60 % acetonitrile in water (B) and the flow rate was 1.0 mL min^{-1}. The gradient used for the separation consisted of 10 % B traversing to 51 % B in a ten-minute use of a convex curve (No. 5). A washing step was then programmed to 100 % B in order to clean any residual sample components from the column.

Tryptophan was determined spectrometrically (Perkin -Elmer UV/VIS Lambda 16 spectrometer), after hydrolysis with 5 mol L^{-1} NaOH according to Spies' and Chambers' method (8) modified by Shamanthaka (9).

Protein quality

The dietary protein quality of the investigated mushrooms was evaluated by comparison of the essential amino acid content with the reference FAO/WHO pattern of amino acid requirements for pre-school children (two to five years) (10). The lowest essential amino acid being deficient is marked as the limiting amino acid.

Statistical analysis

Statistical data processing was carried out on STAT-GRAPHICS V. 4.0 and Microsoft Excel 97 softwares.

Results and discussion

The Kjeldahl nitrogen content, protein data and dry matter contents of the fifteen Macedonian edible Boletaceae mushrooms expressed as a percentage on a dry mass basis are listed in Table 1. The dry matter content in the investigated Macedonian edible Boletaceae mushrooms, ranging from 6.5 (*Suillus granulatus*, Shtip) to 17.6 % (*Boletus edulis*, Kavadarci), is relatively low when compared to other foods (11). The average dry matter value of 10.6 is comparable with the theoretical value of 10 % dry matter in mushrooms, which is always used in the literature data when this investigation is not done. Kjeldahl nitrogen varied from 3.6 (*Suillus granulatus*, Probishtip) to 6.6 % (*Boletus edulis*, Kavadarci) which multiplied with the conversion factor 6.25 for proteins amounts to a 22.3-41.3 % protein. The fruiting bodies of the mushrooms contain a number of unusual nitrogenous compounds which may interfere with the commonly used Kjeldahl nitrogen analysis and imply higher protein content values for mushrooms than given in the literature. The net (true) protein values were lower (14.4-26.3 %), even though the obtained protein content was still higher than that of most natural products. *Boletus edulis* samples collected from Krushevo (26.3 %) and Vratnica (25.5 %) contained the highest net proteins levels, whereas *Suillus granulatus* from Probishtip and *Leccinium aurantiacum* from Delchevo were the poorest in net proteins (14.4-16.6 %). Net protein nitrogen value compared with total nitrogen content was apparently different between species and ranged between 62.9 and 72.7 %. Since the Kjeldahl method does not distinguish between protein and non-protein nitrogen, the average value of 66.7 % and a practical nitrogen -protein conversion factor 4.17 might be used for evaluation of the net protein content in the Macedonian edible Boletaceae mushrooms. This coincides with Ogawa's (12) results of 65 % protein nitrogen in mushrooms from Japan and Stankeviciene's (13) value of 69.8 % protein nitrogen for Lithuanian mushrooms.

The dry matter content in the investigated mushrooms samples is not significantly correlated with the total nitrogen ($p>0.05$; $t=1.66$) and net proteins content ($p>0.05$; $t=1.57$).

The amino acid composition of the fifteen investigated Macedonian edible mushroom samples from the Boletaceae family is presented in Tables 2 and 3. All of the eighteen investigated amino acids, including the essential ones, were present in all mushroom proteins. Among amino acids, threonine, alanine, arginine, cysteine and aspartic acid predominated. These data coincide with Fujita's (14) assumption that aspartic acid and alanine are the most abundant amino acids constitutive of mushroom proteins. Among amino acids, tryptophan was present in the lowest amount, but still meeting the tryptophan requirements. Some authors (15) state that mushrooms are

good sources of this amino acid and report the value of 11-20 g kg^{-1} protein, which is in agreement with our average tryptophan value of 10.56 g kg^{-1} protein. The lowest concentration of total amino acids of 16.7 % was found in *Suillus granulatus* from Probishtip and the highest amino acids concentration of 30.6 % was found in *Boletus edulis* from Krushevo. The amino acid pattern was different in all studied samples, but the quantitative ratios were identical in mushrooms of the same genus. The content of aromatic amino acids in all investigated samples was consistent at about 4.2 % (*Leccinium aurantiacum*, Delchevo) to 14.6 % (*Boletus edulis*, Vratnica) of the total amino acids. The average value of 8.7 % aromatic acid found in this report was lower than that reported by Vetter (16) in mushrooms of various Russula and Agaricus species (10.8 % on average). The average sulphur amino acids content of 11.60 % of the total amino acids in the mushrooms analyzed was higher if compared with the average value of 4.6 % found by Vetter (16). Acid amino acids accounted for 5.3 % of total amino acids in Boletus edulis from Vratnica to 20.6 % in Suillus granulatus from Probishtip. The content of heterocyclic amino acids varied in concentration limits from 3.3 % (*Boletus edulis*, Vratnica) to 10.4% (*Leccinium aurantiacum*, Delchevo). Aliphatic monoamino monocarbonic amino acids proved to be more abundant than other investigated amino acids and were present in 48.8% on average. Overall differences in regard to the content of each amino acid per net protein (Table 3) could be noticed in different investigated samples. This confirmed the fact that amino acid content depends on botanical origin. Comparison with other food proteins (17) of vegetable (wheat, potato, tomato, banana) and animal (beef, milk) origin indicated that mushroom proteins have a higher proportion of glycine, arginine, threonine, alanine, tyrosine, methionine, cysteine and isoleucine and a lower proportion of serine, phenylalanine and lysine. An increase in the proportion of eight amino acids in comparison the a decreased proportion of three amino acids still reflects the high nutritive value of mushroom proteins. The average net protein value of 20.8 % in Macedonian edible Boletaceae mushrooms (Table 1) was higher than that in vegetable food (3.9 % banana, 12.4 % tomato) and lower than that in food of animal origin (24.9 % milk, 70.0 % beef meat).

By comparing the obtained amino acid values from fifteen species of Macedonian edible mushrooms from the Boletaceae family with the proposed reference FAO/WHO protein pattern (10), the following parameters were calculated and are presented in Table 4: E:N (ratio of essential to non -essential amino acid), E:T (ratio of essential to total amino acids), BV (biological value), PER (protein efficiency ratio), A/T (chemical score), EAAI (essential amino acid index), LAA (limiting amino acid) and X (percent limiting amino acid storage). The results show that E:N, E:T and E:P ratios were highest in *Boletus luridus* from Probishtip and lowest in *Boletus edulis* from Kavadarci. The biological value of the investigated mushrooms fluctuated from 51.3 % (*Boletus edulis*, Delchevo) to 78.9 % (*Suillus granulatus*, Probishtip). Compared to the recent FAO reference pattern (10), lysine was the most limiting essential amino acid in the Macedonian edible Boletaceae mushrooms. According to the PER value, two *Boletus edulis* samples from Krushevo and Ograzden and one *Suillus granulatus* sample from Probishtip could serve as a source of high-quality proteins. Six samples of *Boletus edulis* (from Radovish, Veles, Gostivar, Vratnica, Kavadarci and Probishtip) and samples of *Suillus granulatus* (Shtip) and *Leccinium aurantiacum* (Delchevo) have medium-quality proteins. Low-quality proteins were estimated in two samples of Boletus edulis (from Kichevo and Delchevo) and in both the Boletus luridus samples (from Ljuboten and Probishtip). Nutritional value parameters (10) for some other proteins such as that for 70-80 % wheat flour, soybean and beef meat, were used comparatively (Table 4). According to the BV parameter, the data indicated that eight of the fifteen investigated mushroom proteins were of higher quality than the soybean protein, which is in all literature reports marked as having a nutritional value similar to that of animal proteins (2). However, this did not apply to the EAAI value. *Suillus granulatus* from Probishtip showed the highest biological value, but the EAAI value is not highest because the EAAI calculations include all the essential amino acids ratios compared to BV' while only the lowest amino acid ratio is included. The EAAI values showed that in the investigated wild Macedonian edible Boletaceae mushrooms, all the essential amino acids, except the limiting one, were present in quantities meeting dietary requirements.

Conclusion

Due to their botanical origin, the amino acid content and protein nutritional parameters of the investigated wild Macedonian edible Boletaceae mushrooms showed considerable differences.

Macedonian edible mushrooms, when compared to other food sources, contain greater protein quantity and represent a good protein food source.

A nitrogen to protein converting factor of 4.17 was obtained for the investigated Macedonian edible Boletaceae mushrooms.

Table 1. Dry matter, Kjeldahl nitrogen, crude and net protein content in the investigated mushrooms samples (% dry mass)

Sample (location)	Dry matter	Nitrogen	Crude protein (N x 6.25)	Net protein
Boletus edulis s.l. Bull.: Fr. (Radovish)	10.99	4.52	28.25	17.78
Boletus edulis s.l. Bull.: Fr. (Veles)	13.04	5.11	31.94	21.52
Boletus edulis s.l. Bull.: Fr. (Kitchevo)	13.93	5.38	33.62	23.76
Boletus edulis s.l. Bull.: Fr. (Krushevo)	12.31	6.61	41.31	26.35
Boletus edulis s.l. Bull.: Fr. (Gostivar)	12.47	5.44	34.00	22.40
Boletus edulis s.l. Bull.: Fr. (Delchevo)	17.59	5.60	35.00	22.42
Boletus edulis s.l. Bull.: Fr. (Vratnica)	15.63	5.62	35.12	25.50
Boletus edulis s.l. Bull.: Fr. (Ograzden)	14.32	5.19	32.44	22.72
Boletus edulis s.l. Bull.: Fr. (Kavadarci)	17.18	4.11	25.69	17.82
Boletus edulis s.l. Bull.: Fr. (Probishtip)	15.29	5.34	33.37	21.64
Boletus luridus Schiff.: Fr. (Ljuboten)	9.82	4.52	28.25	19.75
Boletus luridus Schiff.: Fr. (Probishtip)	13.29	4.87	30.44	20.24
Suillus granulatus (L.:Fr.) O.Kuntze (Shtip)	6.46	4.33	27.06	19.67
Suillus granulatus (L.:Fr.) O.Kuntze (Probishtip)	10.79	3.57	22.31	14.36
Leccinium aurantiacum (Bull.) S.F.Gray (Delchevo)	9.46	4.15	25.94	16.58

Table 4. Protein nutritional parameters

Sample (location)	E:N	E:T	E:P	BV	PER	A/T	EAAI	LAA	X
Boletus edulis s.l. Bull.: Fr. (Radovish)	1.64	0.62	0.72	58.05	1.54	30.68	0.78	Leu	69.32
Boletus edulis s.l. Bull.: Fr. (Veles)	0.98	0.49	0.58	61.44	1.71	36.03	0.68	Lys	63.96
Boletus edulis s.l. Bull.: Fr. (Kitchevo)	1.03	0.51	0.59	55.65	1.42	26.90	0.52	Lys	73.10
Boletus edulis s.l. Bull.: Fr. (Krushevo)	1.65	0.62	0.72	69.32	2.11	48.45	1.35	Lys	51.55
Boletus edulis s.l. Bull.: Fr. (Gostivar)	1.03	0.51	0.59	61.55	1.72	36.21	0.73	Lys	63.79
Boletus edulis s.l. Bull.: Fr. (Delchevo)	1.32	0.57	0.66	51.28	1.20	20.00	0.89	Lys	80.00
Boletus edulis s.l. Bull.: Fr. (Vratnica)	1.55	0.61	0.70	59.15	1.60	32.41	1.30	Lys	67.59
Boletus edulis s.l. Bull.: Fr. (Ograzden)	1.31	0.57	0.66	76.64	2.49	60.00	1.22	Leu	40.00
Boletus edulis s.l. Bull.: Fr. (Kavadarci)	0.88	0.47	0.54	59.06	1.59	32.27	0.51	Leu	67.73
Boletus edulis s.l. Bull.: Fr. (Probishtip)	0.89	0.47	0.54	62.87	1.79	38.27	0.81	Lys	61.72
Boletus luridus Schiff.: Fr. (Ljuboten)	1.50	0.60	0.70	55.12	1.40	26.06	0.85	Leu	73.94
Boletus luridus Schiff.: Fr. (Probishtip)	3.05	0.75	0.87	55.22	1.40	26.21	0.92	Leu	73.79
Suillus granulatus (L.:Fr.) O.Kuntze Shtip)	2.27	0.69	0.81	64.44	1.87	40.79	1.31	Leu	59.24
Suillus granulatus (L.:Fr.) O.Kuntze (Probishtip)	1.28	0.56	0.65	78.94	2.60	63.63	0.91	Lys	36.36
Leccinium aurantiacum (Bull.) S.F.Gray (Delchevo)	1.40	0.58	0.68	61.01	1.69	35.36	0.72	Lys	64.64
beaf meat 70-80 % wheat flour soybean				85.00	2.90	73.20			26.80
				57.50	1.50	29.80			70.20
				59.90	1.60	33.50			66.50

*E:N (ratio of essential to non-essential amino acid), E:T (ratio of essential to total amino acids), BV (biological value), PER (protein efficiency ratio), A/T (chemical score), EAAI (essential amino acid index), LAA (limiting amino acid) and X (percent limiting amino acid storage)

Table 3. Amino acid content in wet proteins (g per 16 g of N and per 100 g wet protein)

Sample (location)	Asp	Glu	Ser	Gly	His	Arg	Thr	Ala	Pro	Tyr	Val	Met	Cys2	Ile	Leu	Phe	Lys	Trp
Boletus edulis s.l. Bull.: Fr. (Radovish)	5.12	6.47	5.12	6.97	7.87	4.61	28.68	4.72	10.97	4.33	3.20	4.89	9.17	2.98	2.02	5.29	2.92	0.90
Boletus edulis s.l. Bull.: Fr. (Veles)	6.74	4.79	2.09	7.34	5.44	7.53	17.33	23.8	6.74	4.92	3.76	5.02	9.43	4.37	2.46	1.58	2.09	0.74
Boletus edulis s.l. Bull.: Fr. (Kitchevo)	4.97	4.84	2.02	11.83	7.24	11.07	10.27	17.0	5.55	5.22	7.95	5.93	8.12	7.11	2.10	2.61	1.56	0.80
Boletus edulis s.l. Bull.: Fr. (Krushevo)	6.03	3.38	0.99	5.77	3.60	7.97	20.42	13.9	5.84	8.96	5.01	2.01	11.12	6.11	5.39	6.07	2.81	0.83
Boletus edulis s.l. Bull.: Fr. (Gostivar)	3.57	4.02	1.96	7.32	4.73	12.32	14.20	24.1	3.88	6.38	3.97	5.80	10.62	5.85	3.48	0.85	2.10	1.03
Boletus edulis s.l. Bull.: Fr. (Delchevo)	16.23	4.64	0.58	4.06	3.39	12.80	10.75	8.70	3.08	10.48	5.75	8.07	16.15	2.63	1.96	4.99	1.16	0.85
Boletus edulis s.l. Bull.: Fr. (Vratnica)	3.29	2.86	0.90	5.92	4.47	11.45	7.72	19.1	2.08	13.53	5.02	7.84	15.76	5.65	3.49	3.49	1.88	1.72
Boletus edulis s.l. Bull.: Fr. (Ograzden)	5.72	4.27	2.46	6.73	2.29	12.98	24.21	13.2	4.93	6.03	5.94	6.51	5.63	3.65	3.96	3.08	3.65	0.92
Boletus edulis s.l. Bull.: Fr. (Kavadarci)	12.18	6.56	3.76	9.09	6.00	2.75	18.80	21.9	5.39	7.63	2.19	3.53	4.77	4.54	2.13	1.96	2.24	0.73
Boletus edulis s.l. Bull.: Fr. (Probishtip)	9.47	6.98	5.27	10.07	5.27	8.41	3.79	12.0	8.92	5.82	8.96	6.65	3.97	4.67	8.50	3.42	2.22	1.80
Boletus luridus Schiff.: Fr. (Ljuboten)	6.78	9.11	1.26	9.82	6.33	10.94	35.90	3.75	4.91	3.59	8.10	3.29	4.51	1.67	1.72	1.32	1.82	1.72
Boletus luridus Schiff.: Fr. (Probishtip)	5.14	2.72	1.58	8.55	4.59	4.89	52.32	2.86	2.96	9.49	4.79	3.95	2.72	1.78	1.73	1.63	3.90	0.59
Suillus granulatus (L.:Fr.) O.Kuntze (Shtip)	4.83	4.22	2.39	5.54	2.49	9.66	32.59	4.02	4.88	5.49	4.27	8.18	10.47	7.83	2.69	2.85	2.90	0.91
Suillus granulatus (L.: Fr.) O.Kuntze (Probishtip)	19.92	4.04	2.65	3.48	10.93	12.39	7.45	3.97	4.60	5.71	5.43	4.18	13.72	2.99	5.99	4.11	3.69	0.97
Leccinium aurantiacum (Bull.) S.F.Gray (Delchevo)	15.74	4.22	3.01	6.63	5.55	3.68	36.13	4.22	10.80	3.38	6.51	2.65	2.53	3.26	3.01	1.51	2.05	1.33

Sample (location)	Asp	Glu	Ser	Gly	His	Arg	Thr	Ala	Pro	Tyr	Val	Met	Cys2	Ile	Leu	Phe	Lys	Trp
Boletus edulis s.l. Bull.: Fr. (Radovish)	0.91	1.15	0.91	1.24	1.40	0.82	5.10	0.84	1.95	0.77	0.57	0.87	1.63	0.53	0.36	0.94	0.52	0.16
Boletus edulis s.l. Bull.: Fr. (Veles)	1.45	1.03	0.45	1.58	1.17	1.62	3.73	5.13	1.45	2.25	0.48	0.99	1.41	0.94	0.53	0.34	0.45	0.16
Boletus edulis s.l. Bull.: Fr. (Kitchevo)	1.18	1.15	0.48	2.81	1.72	2.63	2.44	4.04	1.32	1.24	1.89	1.41	1.93	1.69	0.50	0.62	0.37	0.19
Boletus edulis s.l. Bull.: Fr. (Krushevo)	1.59	0.89	0.26	1.52	0.95	2.10	5.38	3.67	1.54	2.36	1.32	0.53	2.93	1.61	1.42	1.60	0.74	0.22
Boletus edulis s.l. Bull.: Fr. (Gostivar)	0.80	0.90	0.44	1.64	1.06	2.76	3.18	5.41	0.87	1.43	0.89	1.30	2.38	1.31	0.78	0.19	0.47	0.23
Boletus edulis s.l. Bull.: Fr. (Delchevo)	3.64	1.04	0.13	0.91	0.76	2.87	2.41	1.95	0.69	2.35	1.29	1.80	3.62	0.59	0.44	1.12	0.26	0.19
Boletus edulis s.l. Bull.: Fr. (Vratnica)	0.84	0.73	0.23	1.51	1.14	2.92	1.97	4.88	0.53	3.45	1.28	2.00	4.02	1.44	0.89	0.89	0.48	0.44
Boletus edulis s.l. Bull.: Fr. (Ograzden)	1.30	0.97	0.56	1.53	0.52	2.95	5.50	3.01	1.12	1.37	1.35	1.48	1.28	0.83	0.90	0.70	0.83	0.21
Boletus edulis s.l. Bull.: Fr. (Kavadarci)	2.17	1.17	0.67	1.62	1.07	0.49	3.35	3.91	0.96	1.36	0.39	0.63	0.85	0.81	0.38	0.35	0.40	0.13
Boletus edulis s.l. Bull.: Fr. (Probishtip)	2.05	1.51	1.14	2.18	1.14	1.82	0.82	2.60	1.93	1.26	1.94	1.44	0.86	1.01	1.84	0.74	0.48	0.39
Boletus luridus Schiff.: Fr. (Ljuboten)	1.34	1.80	0.25	1.94	1.25	2.16	7.09	0.74	0.97	0.71	1.60	0.65	0.89	0.33	0.34	0.26	0.36	0.34
Boletus luridus Schiff.: Fr. (Probishtip)	1.04	0.55	0.32	1.73	0.93	0.99	10.59	0.58	0.60	1.92	0.97	0.80	0.55	0.36	0.35	0.33	0.79	0.12
Suillus granulatus (L.:Fr.) O.Kuntze (Shtip)	0.95	0.83	0.47	1.09	0.49	1.90	6.41	0.79	0.96	1.08	0.84	1.61	2.06	1.54	0.53	0.56	0.57	0.18
Suillus granulatus (L.: Fr.) O.Kuntze (Probishtip)	2.86	0.58	0.38	0.50	1.57	1.78	1.07	0.57	0.66	0.82	0.78	0.60	1.97	0.43	0.86	0.59	0.53	0.14
Leccinium aurantiacum (Bull.) S.F.Gray (Delchevo)	2.61	0.70	0.50	1.10	0.92	0.61	5.99	0.70	1.79	0.56	1.08	0.44	0.42	0.54	0.50	0.25	0.34	0.22

References

1. J. Vetter, *Z. Lebensm.-Unters. Forsch.* **3** 224-227 (1993).
2. M. Friedman, *J. Agric. Food Chem.* **44** 6-29 (1996).
3. M. Moser, *Die Röhrlinge und Blätterpilze, Kleine Kryptogamenflora,* Band II b/2, Gustav Fisher Verlag, Stuttgart, 1983.
4. AOAC *Official Methods of Analysis,* 15th ed. Association of Official Analytical Chemists, Arlington, VA 1990.
5. *FAO Nutritional Studies. Amino acid content of foods and biological data of proteins,* Rome 1970.
6. B. Bidlingmeyer, S. Cohen and T. Tarvin, *J. Chromatogr*. **336** 93-104 (1984).
7. D.R. Koop, E.T. Morgan, G.E. Tarr and M.J.Coon, *J. Biol. Chem.* **257** 8472-8480 (1982).
8. J.R. Spies and D. C. Chambers, *Anal. Chem.* **21** 1240-1266 (1949).
9. M.C. Shamanthaka and D.R. Sastry, *J. Sci. Food Agric*. **37** 535-538 (1986).
10. FAO/WHO Protein Quality Evaluation, *Food and Agricultural Organization of the United Nations*, Rome 1991.
11. S.W. Souci, W. Fachmann, H. Kraut, *Food Composition and Nutrition Tables*. Meddpharm-Scientific Publishers, Stuttgart, 1994.
12. T. Ogawa, Y. Oka and K. Sasaoka, *J. Food Sci*. **52** 154-157 (1987).
13. D. Stankeviciene and V. Urbomas, *Liet. TSR Mokslu Akad., Ser.* C **4** 109-114 (1988).
14. T. Fujia, H. Kumori, S. Komemushi and K. Yamagata, Lett. *Appl. Mikrobiol*. **10** 137-139 (1990).
15. P. Surinrut, K. Julhamn and L. Njaa, *Qual. Plant.-Plant Foods Hum. Nutr.* **37** 117-125 (1987).
16. J. Vetter, *Z. Lebensm.-Unters. Forsch.* **197** 381-384 (1993).
17. F. Sosulski and G. Imafidon, *J. Agric. Food Chem.* **38** 1351-1356 (1990).

Резиме

Оценка на квалитетот на протеините на некои македонски јадливи габи од фамилијата Boletaceae

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Хранливата вредност на протеините на сите јадливи габи не е еднаква и е зависна од релативниот удел на секоја аминокиселина. Според тоа, целта на оваа студија беше да се одреди количеството на поодделните аминокиселини во вкупните протеини, со што ќе се овозможи утврдување вредности на параметри за оценување на хранливата вредност на протеините на јадливите габи и нивно вреднување како протеински намирници. Во ова испитување беа вклучени 15 примероци на самоникнати видови јадливи габи од фамилијата Boletaceae, собрани од различни подрачја на Македонија. По претколонска дериватизација на аминокиселините во кисели хидролизати со фенилизотиоцијанат (PITC) со HPLC метод е определувана содржината на 17 аминокиселини. Триптофанот е определуван со спектрофотометриски метод во базни хидролизати. Хранливата вредност на протеините во испитуваните габи оценета е врз основа на содржината на есенцијалните аминокиселини во однос на истите аминокиселини во предложениот модел од ФАО/СЗО. Во зависност од потеклото и од видот на плодоносните тела на испитуваните примероци јадливи габи, есенцијалните аминокиселини се застапени од 47-75 %. Најчесто најдена лимитирачка аминокиселина е лизинот. Повеќето од испитаните видови јадливи габи од фамилијата Boletaceae имаат висока биолошка вредност, висок индекс на ефикасност и високо место во хемиската скала на протеини. Биолошката вредност на протеините на испитуваните примероци јадливи габи се движи во граница од 51,3 до 78,9 %. Вкупните присутни аминокиселини застапени околу 66,7 % во вкупниот азот на испитуваните примероци, ја наметнуваат потребата од намалена вредност (4,17) на протеински конверзационен фактор за овие видови македонски јадливи габи.