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AMINO ACID COMPOSITION OF BEANS AND LENTIL *

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ABSTRACT

The amino acid composition of raw seeds, lyophilised cooked seeds and the water soluble matter from cooking of three varieties of Slovenian common beans (*Phaseolus vulgaris*), namely Češnjevec, Semenarna 22 and Cipro, and of the French green lentil (*Lens esculenta*) Anicia was determined. For the raw seeds, crude protein contents vary from 21.5, 23.5 and 26.2 g per 100 g of dry matter for the Češnjevec, Cipro and Semenarna 22, respectively, and 26.7 g in the lentil. However, non-protein N is higher in the lentil than in the beans. The contens of amino acids in beans are similar, whereas for the lentil concentrations of methionine and tyrosine are lower and the concentration of arginine much higher than for the beans. After cooking the amount of some amino acids (in 100 g of crude protein) increased, especially tyrosine, methionine and cystine, more in lentil and less in beans. The EAAI was higher in beans than in lentil and was increased after cooking the legumes. CS increased after cooking by more than 100 % for the lentil and 20 % for the beans. Analysis of the material obtained by drying the cooking water showed that predominantly non-essential amino acids were present in this fraction.

Key words: legumes / *Phaseolus vulgaris* / *Lens esculenta* / animal nutrition / human nutrition / amino acids / EAAI

AMINOKISLINSKA SESTAVA FIŽOLA IN LEČE †

IZVLEČEK

Vsebnost aminokislin smo določili v surovih in kuhanih liofiliziranih vzorcih semen in v suhi snovi vode po kuhanju treh slovenskih sort fižola (*Phaseolus vulgaris*): češnjevec, semenarna 22 in cipro ter francoske sorte zelene leče (*Lens esculenta*) anicia. Vsebnost surovih beljakovin v surovih vzorcih je nihala med 21,5 g in 23,5 g do 26, 2 g v 100 g surovih beljakovin pri češnjevcu, cipru oz. semenarni 22 in 26,7 g pri leči. Vsebnost ne-beljakovinskega N je bila večja v leči kot v fižolih. Med posameznimi fižoli je aminokislinska sestava podobna, v primerjavi s surovo lečo pa vsebujejo surovi fižoli več metionina in tirozina ter manj arginina. Po kuhanju se je vsebnost (v 100 g surovih beljakovin) nekaterih aminokislin povečala, še posebej tirozina, metionina in cistina, bolj pri leči kot pri fižolih. Izračunani IEAK je bil večji pri vzorcih fižolov kot pri leči in se je izboljšal po kuhanju metuljnic. KI se je po kuhanju povečal za več kot 100 %

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pri leči in povprečno za 20 % pri fižolih. Analiza suhe snovi vode je pokazala, da so v tej frakciji prisotne predvsem ne-esencialne aminokisline.

Ključne besede: metuljnice / *Phaseolus vulgaris* / *Lens esculenta* / prehrana živali / prehrana ljudi / amino kisline / IEAK

INTRODUCTION

Plant proteins represent the primary source of food proteins for humans and animals. More than two thirds of these primary food proteins come from cereal and legume seeds. Together with proteins, legume seeds provide a high proportion of carbohydrates, starch and fibres. With reference to the recommended daily allowances (Barasi, 1997) of humans as well as of monogastric domestic animals and poultry, the amino acid composition of legumes is unbalanced, 80 % of their proteins being specific storage proteins. Protein quality is affected by essential amino acid composition, amino acid imbalance, digestibility and biological availability of the amino acids, and by the antinutritional activity of some components of the seeds (Deshpande and Damodaran, 1990). In general, legumes are rich in lysine, but deficient in sulphur containing amino acids (methionine and cystine). However, with a small increase in one of these two amino acids, tryptophan would become the next limiting amino acid in legume seeds.

Except for the case of peanuts, the preparation of legume seeds for human consumption invariably involves some rehydration and heating. Hydration results in softering and swelling, and heating results in denaturation of proteins. The reason for processing of dry legume seeds is first developing aroma and softening the seeds, but a more important reason is in inactivation of antinutritional factors such as trypsin inhibitor and lectins present in the raw seeds.

Previous studies stressed differences in the chemical composition between defined varieties of raw and cooked Slovenian beans (Stekar *et al.*, 1997). We became interested in studying the effect of cooking on the chemical composition in relation to their nutritional value (Pirman *et al.*, 2001).

Average values of bean and lentil amino acid composition can be found in nutrition tables. However, most published data on composition is related to the raw, rather than to the cooked seeds. Information about the amino acid composition of defined varieties of beans or lentils are rare. Data about the amino acid composition of Slovenian varieties of beans were not found in the literature.

Thus the aim of our work was to determine the differences in amino acid composition of proteins of three cultivars of Slovenian common beans and a comparison with the amino acid composition of the green French lentil, since lentils and common beans are very popular food in both countries, and known to contain a high amounts of crude proteins. Amino acid composition was determined in raw and cooked samples. Interest was also given to the composition of the material found in the cooking water. Some home cooking recipes use the water left over from cooking beans or lentil for preparing other dishes, but in the literature we did not find any information about the nutritional value of soluble material in the water used for cooking legumes.

MATERIAL AND METHODS

Three most widely consumed varieties of Slovenian common beans (*Phaseolus vulgaris*), Češnjevec, Semenarna 22 and Cipro were used, from the 1997 harvest. Samples of bean were obtained at the supplier, Semenarna Ljubljana, and guaranteed to be of a single, known species for each sample. Češnjevec and Semenarna 22 beans are autochthonous Slovenian varieties, while Cipro is an international seed variety, however Semenarna Ljubljana has its own selection

and distribution of these seeds. Češnjevec is classified as a low bean, cultivated for seeds, and grown in upright, low and wide bushes. The seed is longish, of light brown colour and tasty. Cipro is classified as tall climbing bean, which needs support and is used in pods and as dry seeds. It is red coloured, the seeds are longish and of excellent taste. Semenarna 22 is classified as tall climbing bean grown for seeds, and dark brown in colour.

A defined sample of the lentil *Lens esculenta puyensis var. Anicia* (Lentille Verte du Puy) from the 1997 harvest was sent from Cilverpuy, Le Puy (France). The seed of this variety is a green microsperma with yellow cotyledons and a blue transparent envelope; the mature bushy plant reaches 30 cm. The Anicia cultivar grown in specified conditions in the officially limited area of the Le Puy region qualifies for certification (Appellation d'origine controlée).

Preparation of samples

Legume samples to be analyses raw were ground in a cyclone mill (Tecator, mesh 1 mm) to flour and subjected to analysis.

Legume samples to be analysed after cooking were cooked according to the custom of cooking beans in Slovenia. The time of soaking and cooking and the amount of water for each bean cultivar was set precisely as follows. Before cooking, an aliquot of sample (~ 200 g) was soaked for 18 hours at room temperature in 2 volumes of water and cooked the next day in the same unsalted water. Češnjevec bean was boiled for 50 minutes, while Semenarna 22 and Cipro beans were boiled for 55 minutes. The lentil Anicia was cooked according to the instructions of the producer: no soaking necessary, cooking in 3 volumes of unsalted tap water, kept at boiling temperature for 20 minutes. During cooking of legumes the cooking pot was covered.

After cooking, the water was decanted, the cooked seeds were lyophilised and ground into flour with the cyclone mill. The water separated from the cooked legumes, was lyophilised and the dry substance was ground and prepared for analysis.

Chemical analyses

Nitrogen content, determined by the Kjeldhal method, is always expressed with reference to the dry matter of the sample. Crude protein was calculated from the N content, using the 6.25 coefficient. True protein was determined following the Bernstein method (Methodenbuch, 1997). Each aliquot of the sample was analysed at least twice.

The amino acid analyses were performed by HPLC after hydrolysis of the flour samples with 6 N HCl at 110 °C under vacuum for 24 hours on an amino acid analyser (Applied Biosystems 421 amino acid analyser) according to More and Stein (1963). Results of analysis are expressed with reference to the N content of the sample: g/100 g of crude protein (N x 6.25).

The quality of amino acid composition was tested using the essential amino acid index (EAAI) and the chemical score (CS) determined according to literature data (McDonald *et al.*, 1995).

Data were analysed by the analysis of variance (ANOVA) procedures (SAS, 1989) with SAS software, taking into consideration the variety of the legumes or the variety of legume species as the only main factor (T-test). Data are expressed as least square means (LSM). If it is not stated otherwise, a least significant difference of 0.05 was used to separate the variety mean values.

RESULTS AND DISCUSSION

Content of amino acids in the raw seeds of beans and lentil

The amino acid compositions of raw legumes is shown in Table 1. The concentrations of amino acids are not different in 3 bean varieties, except for tyrosine which is higher in Češnjevec than in Semenarna 22. Lentil presents the same profile as beans, except for methionine, tyrosine and serine, which are lower, and arginine, which is higher in lentil than in beans.

Table 1. Amino acid composition of raw beans and lentil seeds (g AA per 100 g of crude protein) *
Preglednica 1. Povprečna aminokislinska sestava surovih fižolov in leče (g AK v 100 g surovih beljakovin) *

	BEANS / FIŽOLI			LENTIL / LEČA
	ČEŠNJEVEC	SEMENARNA 22	CIPRO	ANICIA
THR	4.01 [a]	3.83 [a]	3.86 [a]	3.33 [a]
VAL	5.41 [a]	4.83 [a]	4.82 [a]	4.02 [a]
ILE	4.06 [a]	4.27 [a]	4.24 [a]	3.64 [a]
LEU	7.10 [a]	7.57 [a]	7.35 [a]	6.57 [a]
MET	1.04 [ab]	1.31 [a]	1.16 [ab]	0.59 [b]
CYS	0.09 [a]	0.06 [a]	0.07 [a]	0.07 [a]
PHE	4.96 [a]	5.55 [a]	5.16 [a]	4.67 [a]
TYR	2.94 [a]	2.30 [b]	2.48 [ab]	1.40 [c]
LYS	5.87 [a]	6.72 [a]	6.22 [a]	5.84 [a]
ARG	4.99 [a]	5.81 [a]	5.62 [a]	6.36 [b]
HIS	2.28 [a]	2.57 [a]	2.45 [a]	2.09 [a]
ALA	3.75 [a]	3.77 [a]	3.94 [a]	3.65 [a]
ASP	10.61 [a]	11.52 [a]	10.60 [a]	9.46 [a]
GLU	13.29 [a]	13.76 [a]	13.30 [a]	12.92 [a]
GLY	3.30 [a]	3.19 [a]	3.33 [a]	3.59 [a]
PRO	3.25 [a]	3.46 [a]	3.37 [a]	3.50 [a]
SER	4.85 [ab]	5.03 [a]	4.79 [ab]	3.90 [b]
Sum (g) / vsota (g) **	81.82	85.55	82.76	75.59
Crude protein (g/100 g dry matter) (N x 6.25) Surove beljakovine (g/100g SS)	21.51 [a]	26.23 [b]	23.48 [c]	26.75 [b]
True protein (g/100 g dry matter) Prave beljakovine (g/100g SS)	18.98 [a]	23.48 [bc]	21.10 [ab]	24.13 [c]

* = mean of parallel determinations / povprečje paralelnih določitev
** = sum of all determined amino acids / vsota vseh določenih aminokislin
[a, b, c] = values with different superscripts in the same row are significantly different ($P \leq 0.05$) povprečja, označena z različnimi črkami, so statistično značilna ($p \leq 0,05$)

The amino acid compositions of the beans and lentil determined on raw samples are in agreement with the literature data, except the concentration of cystine and methionine (Mossé and Pernollet, 1983; Deshpande and Damodaran, 1990; Combe *et al.,* 1991; Souci *et al*., 1994; Combe and Cvirn, 1995; Adsule, 1996; Glew *et al*., 1997; Hu *et al*., 1997; Kunachowicz *et al*., 1998). Combe and Cvirn (1995) found a concentration of 1 g of cystine per 100 g of crude protein in the same variety of green lentil, and even more in a blonde variety of lentil (Petite blonde de Dahra) (Combe *et al.,* 1991), after oxidation prior to the 24 h HCl (5.5 M) hydrolysis. Some authors (More and Stein, 1963) reported that under 24-hour hydrolysis in 6 M HCl the concentrations of some amino acids decreased (cysteine by 50–100 %). Mossé (1990) used three different times (15, 24 and 48 hours) of hydrolysis in 6 M HCl, in order to make allowance for losses resulting either from partial degradation or from incomplete release, in addition to an 18 hours hydrolysis of a previously oxidised sample for sulphur amino acids. For checking the accuracy of amino acid determination, he used commercial egg white lysozyme (Merck) and purified human serum albumin (NBC). Namely, another significant problem in this field is that until now there are no certified reference materials to check the accuracy and reproducibility of amino acid determination in the field of food and feed.

The content of amino acids ranges from 82 g to 85 g per 100 g of crude protein for the beans and 75 g per 100g of crude protein for the lentil. The proportion of non-protein nitrogen is high in our samples and is higher in lentil than in beans. Adsule *et al*. (1989) reported on more than 20 % of non-protein nitrogen in the total nitrogen content of lentil seeds. Combe *et al.* (1991) reported on a proportion of 19 % of non-amino acid N for faba bean and a blonde variety of lentils. Our samples of raw beans and lentil differed from literature data in their N and crude protein content, as well as in their true protein (Table 1). The total amount of N is related to conditions of soil, culture and harvest. The amino acid composition of the plant proteins is related to their genetic characteristics, as presented by Mossé and Baudet (1983). Sotelo *at al*. (1995) found more crude protein in wild species of beans than in cultivated ones, but the content of essential amino acids and the chemical score were higher in cultivated beans. For lentils it is known from the literature that they contain a number of unidentified amino acids (Bhatty, 1988). The concentration of unidentified amino acids is greater in cultivated lentils than in wild lentils (Bhatty, 1986).

Content of amino acids in the cooked seeds of beans and lentil

The amino acid compositions of cooked beans and lentil are given in Table 2. Amino acid compositions of Češnjevec and Semenarna 22 are alike except in the phenylalanine and arginine concentrations, which are higher in Semnarna 22 than in Češnjevec. The Cipro composition is lower in isoleucine, leucine and serine than in the other two cooked beans. Compared to beans, the amino acid composition of the cooked lentil is similar, except that it is richer in arginine. The content of amino acids ranges from 80 g in Cipro and 83 g in Anicia to 88 g and 94 g per 100 g of crude protein for Češnjevec and Semenarna 22, respectively.

The effect of the cooking process can be assessed by comparison of Tables 1 and 2. Cooking results in a slight increase in nitrogen content, and an increase in the proportion of amino acids (except for Cipro). It is clearly, shown that a proportion of non-protein N is soluble during the cooking process.

The effect of cooking on the amino acid composition of our samples is presented in Graph 1. The concentrations of most amino acids increased, and especially tyrosine, methionine and cystine in the case of lentil. However, if the amino acids are expressed as g per 100 g of dry sample, which includes the modification of the nitrogen content (Graph 2), the concentrations of all essential amino acids in the cooked legumes decreased compared to the raw legumes. Only

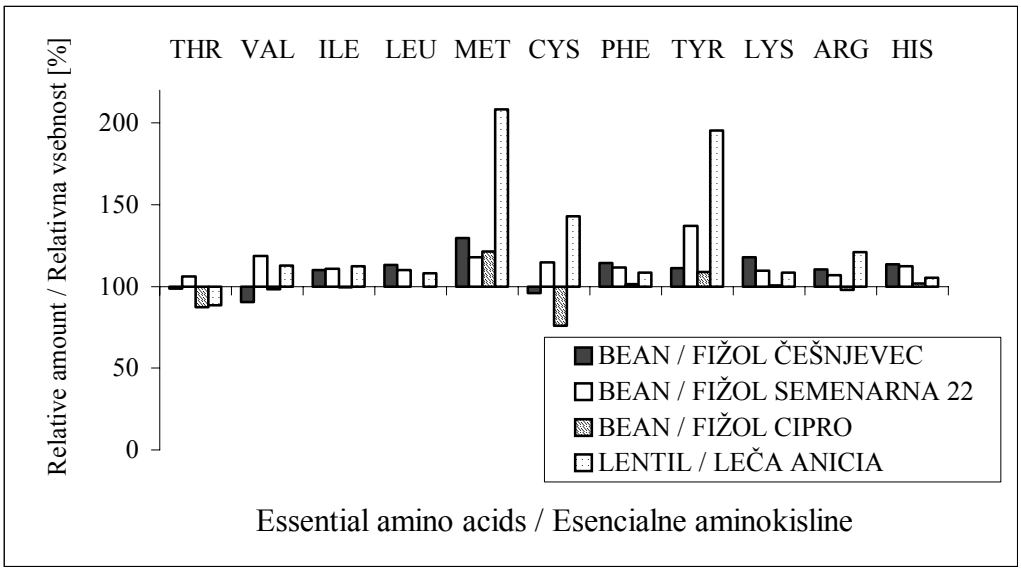
the concentrations of tyrosine and cystine increased on cooking of all 4 legumes. The content of tyrosine is similar in cooked beans and cooked lentil (Table 2).

Table 2. Average amino acid composition of cooked beans and lentil seeds (g AA per 100 g of crude protein) *
Preglednica 2. Povprečna aminokislinska sestava kuhanih fižolov in leče (g AK v 100 g surovih beljakovin) *

	BEANS / FIŽOLI			LENTIL / LEČA
	ČEŠNJEVEC **	SEMENARNA 22	CIPRO	ANICIA
THR	3.96 [a]	4.06 [a]	3.37 [ab]	2.95 [b]
VAL	4.90 [a]	5.72 [a]	4.73 [a]	4.53 [a]
ILE	4.47 [ab]	4.73 [a]	4.21 [b]	4.08 [b]
LEU	8.01 [a]	8.33 [a]	7.34 [b]	7.10 [b]
MET	1.35 [a]	1.54 [a]	1.41 [a]	1.24 [a]
CYS	0.09 [a]	0.07 [ab]	0.05 [b]	0.09 [a]
PHE	5.67 [a]	6.20 [b]	5.23 [a]	5.06 [a]
TYR	3.27 [a]	3.14 [a]	2.71 [a]	2.73 [a]
LYS	6.93 [ab]	7.37 [a]	6.27 [b]	6.34 [b]
ARG	5.52 [a]	6.22 [b]	5.49 [a]	7.68 [c]
HIS	2.59 [ab]	2.89 [a]	2.49 [a]	2.20 [b]
ALA	4.29 [a]	4.27 [a]	3.91 [a]	3.90 [a]
ASP	11.21 [a]	12.29 [a]	9.92 [a]	10.00 [a]
GLU	13.77 [ab]	14.73 [a]	12.09 [b]	13.40 [ab]
GLY	3.44 [a]	3.52 [a]	3.14 [a]	3.83 [a]
PRO	3.65 [a]	3.75 [a]	3.30 [b]	3.75 [a]
SER	5.25 [a]	5.46 [ab]	4.66 [bc]	4.01 [c]
Sum (g) / vsota (g) ***	88.38	94.30	80.33	82.88
Crude protein (N 6.25) (g/100 g dry matter) Surove beljakovine (g/100 g SS)	22.09 [a]	26.57 [b]	24.00 [c]	27.37 [b]
True protein (g/100g dry matter) Prave beljakovine (g/100 g SS)	19.97 [a]	24.79 [b]	22.69 [ab]	23.49 [b]

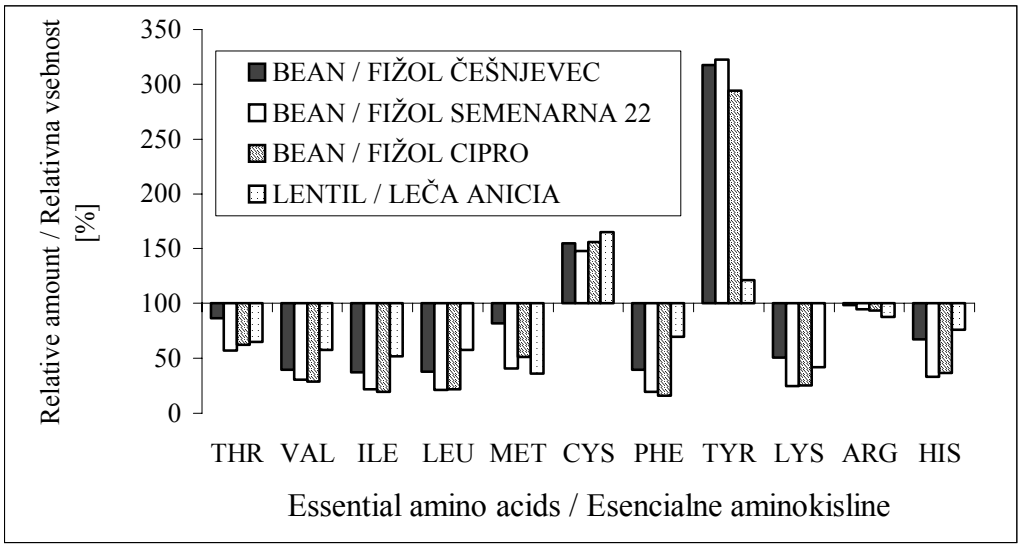
* = mean of parallel determinations / povprečje paralelnih določitev
** = mean of two samples in parallel determinations / povprečje paralelnih določitev dveh vzorcev
*** = sum of all determined amino acids / vsota vseh določenih aminokislin
[a, b, c] = values with different superscripts in the same row are significantly different ($P \leq 0.05$) povprečja, označena z različnimi črkami, so statistično značilna ($p \leq 0,05$)

Candela *et al*. (1997) showed that cooking led to a significant decrease in both essential and non essential amino acids in the common bean (g per 100 g of wet sample). In lentil the same authors found a decrease in the content of isoleucine, leucine and valine, but an increase of lysine, phenylalanine and tyrosine after cooking. A direct comparison cannot be made, since the cooking water was included in the sample of cooked legume. In the albumin fraction of white bean the concentration (g per 16 g of N) of the majority of essential amino acids increased after cooking (Lombardi-Boccia *et al*., 1998), which is in agreement with our results.



Graph 1. Relative amount (%) of essential amino acids in crude protein (g AA per 100 g of crude protein) of beans and lentil after cooking in comparison with values in raw samples.

Grafikon 1. Relativna vsebnost (%) esencialnih aminokislin v surovih beljakovinah (g AK v 100 g surovih beljakovin) fižola in leče po kuhanju v primerjavi z vrednostmi v surovih vzorcih.



Graph 2. Relative amount (%) of essential amino acids in sample (g AA per 100 g of sample) of beans and lentil after cooking in comparison with values in raw samples.

Grafikon 2. Relativna vsebnost (%) esencialnih aminokislin v vzorcu (g AK v 100 g vzorca) fižola in leče po kuhanju v primerjavi z vrednostmi v surovih vzorcih.

Composition of the solid material obtained by lyophilisation of the cooking water

Table 3 gives the composition of the solid material obtained by lyophilisation of the cooking water (soluble fraction), where soluble dry matter was estimated as 5 to 7 % of dry matter from the raw beans and lentil respectively. The nitrogen of this fraction ranged from 4 to 7 % of the nitrogen found in the seeds. However, in the case of beans, the concentration of N found in the soluble fraction was lower than that found in the cooked beans, but in the case of lentil the concentrations of soluble N and that of the cooked lentil N were similar. The sum of the amino acids determined in this soluble fraction reached 72 g per 100 g of crude protein for Češnjevec, but it is lower for the two other bean samples, 64 g and 59 g in Semenarna 22 and Cipro, respectively and it is only 57 g per 100 g of crude protein for the lentil Anicia. This shows that a large proportion of non-protein N is present in this soluble fraction, especially in the lentil sample. Also the proportion of essential amino acids in the total amino acids was low ranging from 34 to 42 %, depending of the legume considered.

Table 3. Composition of dried solids from cooking water *
Preglednica 3. Sestava posušenega trdnega dela vode, po kuhanju metuljnic *

	BEANS / FIŽOLI			LENTIL / LEČA
	ČEŠNJEVEC **	SEMENARNA 22	CIPRO	ANICIA
DM of seeds before cooking (g) Vsebnost SS v semenih pred kuhanjem (g)	178.41	179.65	179.68	184.15
Water soluble matter from cooking (g DM) Vsebnost SS v vodi po kuhanju (g)	8.97	9.14	11.15	13.11
Crude protein (N 6.25) (g/100 g DM) Surove beljakovine (N 6,25) (g/100 g SS)	18.70	18.32	17.71	26.39
% of N in soluble fraction (per N in raw seeds) % N v topni frakciji (glede na N v surovih zrnih)	4.40	3.60	4.70	7.00
Sum of determined AA (g/100 g CP) Vsota vseh aminokislin (g/100 g SB)	72.49	64.27	59.52	57.66
EAA (%) ^{f} EAK (%) ^{f}	42.06	39.85	38.53	34.26

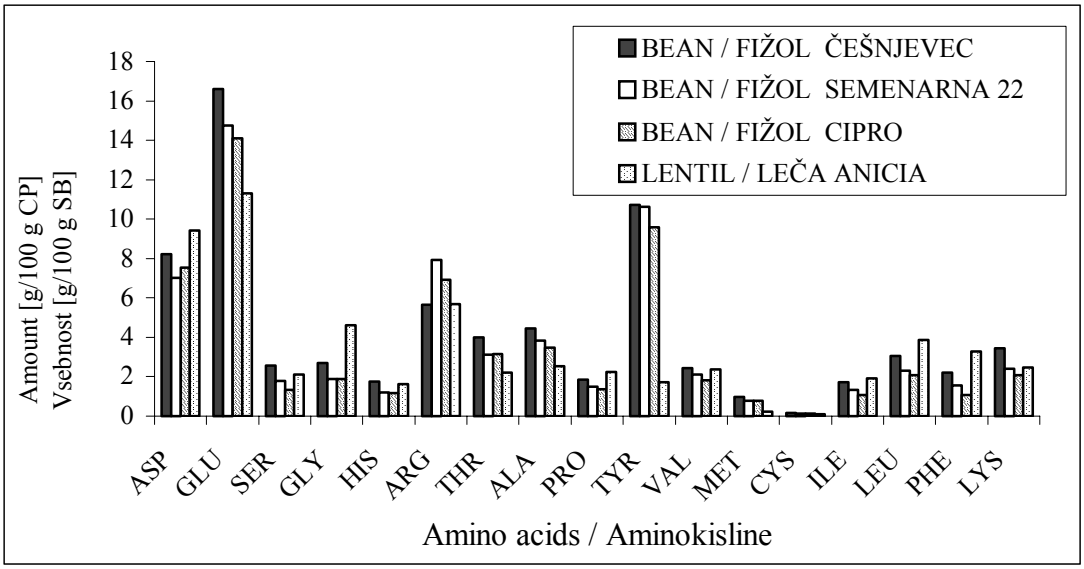
* = mean of parallel determinations / povprečje paralelnih določitev

** = mean of two samples in parallel determinations / povprečje paralelnih določitev dveh vzorcev

^{f} = essential amino acids / esencialne aminokisline

Concentrations of individual amino acids (g/100 g of crude protein) in the dried solids from cooking water are given in Graph 3. Concentrations of cystine, lysine, arginine, histidine, aspartic and glutamic acids are similar in the soluble fraction of N compounds from the beans and lentil. There is a lot of tyrosine dissolved in the water after cooking beans, but not in the

water from cooking lentil. Also this fraction from lentil is lower in methionine, threonine, and alanine and higher amounts of leucine, phenylalanin, glycine and proline than the bean samples. The water containing dissolved substances from cooking beans is used for consumption in Slovenia, and according to our results this practice is demonstrated to provide extra amino acids, including a modest proportion of essential amino acids.



Graph 3. Amino acid composition of the soluble fraction (dried solids) in water used for cooking beans and lentil.

Grafikon. 3. Aminokislinska sestava posušene topne frakcije v vodi uporabljeni za kuhanje fižolov oz. leče.

Protein quality of beans and lentil

Here we calculated the values of the index which has been proposed for assessing the theoretical value of protein used as food or feed. The essential amino acid index (EAAI) of the raw and the cooked legumes, as well as that of the soluble material, are given Table 4.

For the raw legumes, the highest value was obtained for Semenarna 22, and the lowest value from the lentil. After cooking, EAAI value increased in all samples, except in the Cipro bean variety. The highest value was again founf for Semenarna 22 and the lowest for Anicia. The amino acid content of the soluble material provides the lowest values of EAAI, rangeing from 0.30 for Cipro to 0.42 for Češnjevec.

A comparison with egg amino acids confirmed that the limiting amino acids in legumes were sulphur amino acids (Souci *et al.*, 1994). The chemical score (CS) was calculated for methionine. For the raw legumes, the highest CS values were found in Semenarna 22 and the lowest for the lentil Anicia. After cooking, the differences between the legumes were smaller; however the highest CS value was again found for Semenarna 22 and the lowest in lentil Anicia. Cooking resulted in an increase of the chemical score values by more than 100 % in lentil and only by 20 % in beans. As with the EAAI, the amino acid content in the soluble material showed the lowest value for CS in the lentil sample. In beans the limiting amino acid in the soluble fraction in the cooking water was no longer methionine, but isoleucine with a chemical score of 24, 19 and 15 for Češnjevec, Semenarna 22 and Cipro, respectively. These results show that cooking does not have an identical modifying effect on the content of amino acids in the varieties of beans and lentil we studied.

Although there is a larger amount of protein in lentil than in beans, the nutritional quality is not equal to that of beans, as was shown by the values of EAAI (Table 4), and as was confirmed also by the biological value of protein shown in *in vivo* experiments with rats (Tomšič, 1997, Pirman *et al*., 2001).

Table 4. Essential amino acid index (EAAI)* and chemical score (CS) of raw and cooked legumes and in the soluble fraction in the water left over after cooking legumes
Preglednica 4. Indeks esencialnih aminokislin (IEAK)* in kemijski indeks (KI) surovih in kuhanih metuljnic ter v topnem delu v vodi po kuhanju metuljnic

	BEANS / FIŽOLI			LENTIL / LEČA
	ČEŠNJEVEC	SEMENARNA 22	CIPRO	ANICIA
EAAI / IEAK				
Raw samples Surovi vzorci	0.66	0.72	0.69	0.58
Cooked samples Kuhani vzorci	0.73 **	0.80	0.69	0.68
Soluble fraction in the water V vodi topna frakcija	0.42 **	0.34	0.30	0.35
CS / KI ***				
Raw samples Surovi vzorci	30	38	33	17
Cooked samples Kuhani vzorci	39 **	44	40	36
Soluble fraction in the water V vodi topna frakcija	24 **	19	15	6

* = index was calculated from the data on amino acid composition of eggs (Souci *et al*., 1994)
pri izračunu indeksa smo uporabili aminokislinsko sestavo jajca (Souci in sod.., 1994)
** = mean of two samples / povprečje dveh vzorcev
*** = chemical score for amino acid methionine, except for the drained material in water of beans, where it is for amino acid isoleucine / kemijski indeks za aminokislino metionin, razen v suhi snovi vode po kuhanju fižolov, kjer je kemijski indeks izračunan za izoleucin

CONCLUSIONS

Our work has shown that those both legume species, beans and lentil, have a specific amino acid composition: high in lysine and low in sulphur amino acids.

In concordance with the literature we showed that the amino acid composition of three cultivars of beans is similar in the uncooked state. In comparison to the lentil, beans contain more methionine, tyrosine and serine, and less arginine.

We demonstrated that cooking in boiling water results in interesting modifications of the content of amino acids in legumes, as shown by a general increase of the EAAI values. This is explained by the loss into the cooking water of significant amounts of nitrogenous compounds with a low EAA values. However, using the water of cooking for human consumption results in extra N intake, together with all the other soluble nutrients which were not under study in this paper.

POVZETEK

Zrna metuljnic vsebujejo relativno veliko beljakovin, med 200 in 400 g v kg zrn, v primerjavi z nekaterimi drugimi viri rastlinskih beljakovin. Vsebujejo dva- do trikrat več beljakovin kot žita. Vsebnost posameznih aminokislin v beljakovinah je podobna idealni beljakovini za ljudi in živali, z izjemo žveplo vsebujočih aminokislin metionin in cistein. Tudi vsebnost lizina je dva- do trikrat večja v beljakovinah metuljnic kot v beljakovinah žit, kjer je lizin prva limitirajoča aminokislina. Kljub temu pa žita predstavljajo največji delež v hrani za ljudi oz. krmi za živali v večini dežel sveta.

Aminokislinsko sestavo treh slovenskih sort fižola: kultivarji češnjevec, semenarna 22 in cipro smo primerjali med seboj in z zeleno lečo francoskega izvora: kultivar anicia. Za fižol in lečo je znano, da je njuna vsebnost surovih beljakovin relativno velika in podobna. Vsebnost posameznih aminokislin je primerljiva z literaturnimi podatki, razen za aminokislino cistein, kjer je naša vrednost precej nižja.

Aminokislinsko sestavo smo določili v posameznih surovih in kuhanih vzorcih fižolov in leče ter v vodi po kuhanju po štiriindvajseturni kislinski hidrolizi (6 M HCl) pri 110 °C na aminokislinskem analizatorju (HPLC) (More in Stein, 1963).

Surovi vzorci fižolov so si po aminokislinski sestavi precej podobni. Leča vsebuje značilno manj aminokislin serin, tirozin, metionin in izoleucin, ki jih je skupaj v 100 g surovih beljakovin fižolov v povprečju 12,82 ± 0,13, v leči pa 9,53 g. Po kuhanju nastanejo večje razlike med posameznimi vzorci fižolov, še večje razlike pa so v primerjavi z lečo. Po kuhanju so se razlike med fižoli povečale. Najmanjšo vsebnost posameznih aminokislin, predvsem izoleucina, leucina in lizina, smo določili pri kultivarju cipro in največjo pri kultivarju semenarna 22. Kuhani liofilizirani vzorci fižolov vsebujejo v povprečju več predvsem treonina in leucina, medtem ko je vsebnost arginina manjša v primerjavi z lečo. Po kuhanju se relativna vsebnost (% AK v vzorcu po kuhanju glede na vsebnost v surovih vzorcih) posameznih aminokislin v vzorcu zmanjša, razen pri aminokislinah cistein in tirozin. V vodi, ki je ostala po kuhanju metuljnic, smo tudi določili aminokisline. V vodi je večji delež ne-esencialnih aminokilsin v primerjavi z esencialnimi aminokislinami, kar nam je potrdil tudi nizek indeks esencialnih aminokislin (IEAK). Razlika med fižoli in lečo je v značilno večji vsebnosti tirozina v vodi po kuhanju fižolov kot v vodi po kuhanju leče. Med fižoli najbolj odstopa češnjevec. Vsebuje več treonina, fenilalanina leucina in izoleucina ter manj arginina kot ostala dva fižola. Zato je IEAK v vodi po kuhanju najvišji pri češnjevcu, 0,42 in najnižji pri cipru, 0,30, medtem ko je pri semenarni 22 0,34 in leči 0,35. Kljub temu da je vsebnost aminokislin v vodi po kuhanju leče najnižja, je IEAK podoben kot pri fižolih. IEAK je pri surovih vzorcih metuljnic najnižji pri surovi leči (0,58), pri fižolih je bil v povprečju 0,69. Po kuhanju so se indeksi nekoliko izboljšali, pri leči je bil 0,68 in 0,73, 0,80 ter 0,69 pri fižolu češnjevcu, semenarni 22 oz. cipru, kar je potrditev razlik v aminokislinski sestavi med fižoli. Razlika med fižoli in lečo je v značilno večji vsebnosti tirozina v vodi po kuhanju fižolov kot v vodi po kuhanju leče.

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