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ORIGINAL PAPER

NUTRITIONAL VALUE OF RAW LEGUMES*

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Abstract

Legumes should be considered as an important part of a healthy diet, because of both their nutritional value (high protein and low fat content) and functional properties (Trichopoulou et al. 2014). The functional components include carbohydrates, soluble fiber, vitamins and polyphenols. Epidemiological studies have shown a positive correlation between the consumption of legumes and a reduced risk of cardiovascular diseases, diabetes and certain types of cancer. In the past few years, phenolic compounds have attracted much attention owing to a large variety of biological actions, including anti-inflammatory effects, which they can produce (García-Lafuente et al. 2014). Chronic inflammation is a cause of many serious diseases, including cardiac disorders, allergy, DM 1, Alzheimer's disease. In the anti-inflammatory food pyramid, pulses were placed at the base (Viveky et al. 2013). The aim of this study was to determine the content of amino acids, fatty acids, carbohydrates, macro- and micro-elements in the common legumes. The total protein content varied from 17.9 to 22.5 g 100 g^{-1}. The mean content of fat varied from 1.1 to 2.0 g 100 g^{-1} and the soluble sugar content ranged from 4.3 to 7.9 g 100 g^{-1}. The dominant amino acids were glutamic and aspartic acids. Methionine and cysteine composed the lowest percentage of all amino acids. Pulses were characterized by the presence of such fatty acids as α-linoleic, linoleic, oleic and palmitic acid. The mean content of iron varied from 3.3 to 5.3 g 100 g^{-1}. The highest amount of this element was found in small bean, which was also characterized by the highest copper content. The highest amounts of zinc, calcium and magnesium were contained in dark red kidney bean. The analyzed pulses were distinguishd by high nutritive value. The identifed amino acids profile indicates sufficient quantity of lysine and shortage of sulphuric acids. The pulses also had a beneficial composition of fatty acids. The omega-6 to omega-3 ratio was between 1:2 and 4:1.

Keywords: legumes, amino acids, fatty acids, sugars, macro- and micro-elements.

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INTRODUCTION

Legumes like beans, peas, broad beans as well as soyabeans and lentils are an important source of vegetable proteins with a high nutritive value. They are low in fat (except soyabeans), rich in essential fatty acids, have a high amount of vitamin B and contain many macro- and micro-elements like calcium, potassium, magnesium and iron (Rebello et al. 2014). They are also a source of fibre. Moreover, pulses contain many nutritional compounds which play a role in health prophylxis. The seeds of these plants comprise resistant starch and α-galactosides (a culture medium for regular bacterial flora). Legumes are important in the prevention of atherosclerosis, hypertension, heart failure, constipation and large intestine cancer. Epidemiologic investigations have confirmed that proteins isolated from pulses decrease the cholesterol level in blood (Winham, Hutchins 2007, Sirtori et al. 2009). Legumes are characterized by a low glicemic index. Moreover, pulses consumed by diabetics can protect them from cardiovascular complications (Chung et al. 2008, Nöthlings et al. 2008).

Large consumption of pulses takes place in developing countries. Legumes are a less expensive source of proteins than animal food products. Cultivation of pulses is convenient and suitable for crop rotation. Combination of proteins from cereals and pulses ensures a diet of high nutritive value in comparison to a diet containing solely animal proteins (Brazaca, Silva 2003). Moreover, edible plants from this group can prevent anaemia due to iron deficiency. Soyabean, mainly milk from soya, is an alternative for people who have allergy to all cow's milk fractions (Klemola et al. 2002).

Thus far, legumes have been consumed mostly by less wealthy people, while their intake in rich societies has been decreasing. They have been replaced by meat and other high processed products, which are not only a protein source but also contain saturated fatty acids and cholesterol.

The aim of this study was to determine the content of amino acids, fatty acids, sugars and macro- and microelements in common legumes.

MATERIAL AND METHODS

Samples

Samples consisted of four types of raw beans: dark red kidney bean *(Phaseolus vulgaris)*, small bean (*Phaseolus vulgaris, n* = 5), cannellini bean *(Phaseolus vulgaris, n* = 5), runner bean (*Phaseolus coccinus, n* = 5) and one type of pea (whole) (*Cicer Arietrim, n* = 5). The content of total fat, total proteins, fatty acids, amino acids, sugars and selected macro- and microelements (Fe, Zn, Cu, Ca, Mg, Na, K) was determined.

Chemical composition

Moisture of powdered legumes was determined after attaining the constant weight at 105°C (AOAC 1990). Total proteins (N×5.70 for peas; N×6.00 for beans) were determined by the Kjeldahl method (AOAC 1990). Soluble sugars and reducing sugars were determined by the colorimetric method (Dubois et al. 1956). All determinations were carried out with two replications for each sample.

Amino acids analysis

The content of amino acids (except tryptophan) was determined using an AAA-400 Amino Acid Analyzer (INGOS, the Czech Republic). The analytical procedure was applied in line with the relevant recommendations. Freeze-dried material was hydrolyzed in 6 M HCl for 24 h at 110°C. After cooling, filtering and washing, the hydrolyte was evaporated in a vacuum evaporator at a temperature below 50°C for sulfur-containing amino acids and below 60°C for other amino acids, the dry residue being dissolved in a sodium buffer of pH 2.2. Each prepared sample was analyzed using the ninhydrine method. Buffers of pH 2.6, 3.0, 4.25 and 7.9 were applied. Ninhydrine solution was buffered at pH 5.5. A column 370 mm in length was filled with Ostion ANB INGOS ionex (the Czech Republic). The temperature of the column was 55-74°C and that of the reactor was 120°C. The analytic cycle, control and processing of the results were carried out using Chromulan software. Composition of amino acids was expressed in grams per 16 g of N to estimate the quality of the protein in pulses by comparing it with the FAO/WHO pattern (FAO/WHO/UNU 1985).

Analysis of total fat and fatty acids

Total fat composition was determined gravimetrically after petroleum ether extraction (according to the Soxhlet procedure). Extracts were obtained from each sample with ethyl ether as a solvent applied for 5 h at 48±2°C in a Soxhlet extractor following the AACC Method 30-25. Portion of this extract was transmethylated with BF_3 in methanol according to the modification of this method described by Ackman R.G. Methyl esters of fatty acids thus obtained were separated on a PU 4410 gas chromatograph (Philips Scientific Cambridge, GB) with a 105 m capillary column Rtx- 2330 (0.25 mm id; 0.2 µm film thickness, Restek U.S., Benner Circle, Bellefonte, PA). Retention times of various acid methyl esters were determined with standard mixtures such as Supelco 37 component Fame Mix and PUFA No. 1,2,3 (Supelco, Nord Harrison Road Bellefonte, PA). Data processing was carried out using the software Varian LC Workstation (v.5.3). The fatty acid composition of the beans and pea is expressed as a percentage of total fatty acid (AACC 2000).

Analysis of macro- and microelements

20 g samples were weighed and dry-mineralized in a muffle furnace at the temperature of 450°C for ca. 12 hours. Each incinerated sample was dissolved in 65% nitric acid GR (1 cm^3), evaporated and re-combusted for 2 h at the temp. of 450°C. The ash was dissolved in 2M nitric acid (25 cm^3). Elements were determined with atomic adsorption spectrometry using a Varian AA240FS apparatus. Apart from using a calibration curve, the results were verified with the standard addition technique. The average recovery reached about 97-102%.

Statistical analysis

Statistical analysis, including means and ANOVA, was performed using the PC software package Statistica 10.0. Significant differences were determined at the α = 0.05 level according to the analysis of variance with the Duncan's test.

RESULTS AND DISCUSSION

Content of macroelements

Chemical composition of the analyzed legumes is presented in Tables 1-2. The mean content of dry matter of all samples was similar and varied from 84.0% in runner bean to 87.1% in dark red kidney bean (Table 1). The total protein content varied from 17.9 to 22.5 g 100 g^{-1}. The content of fat and soluble sugars was diverse in the analyzed exxtracts. The mean content of fat varied from 1.1 to 2.0 g 100 g^{-1} and that of soluble sugars ranged from 4.3 to 7.9 g 100 g^{-1}. Statistically, the highest values of these compounds were determined for cannellini bean and runner bean. A 100 g portion of pulses covers ca. 1/3 of the daily requirements for proteins by an adult. A similar content of proteins and fat was determined by Khalil, Khan (1995) who investigated the quality of Asian beans. De Almeida Costa et al. (2006) presented a similar content of proteins in pea, bean and other pulses (18.5-21.9 g 100 g^{-1}), but the fat content was significantly higher than our results, varying from 2.2 to 6.7 g 100 g^{-1}. A lower protein content in raw and cooked red bean (16.9-18.0 g 100 g^{-1} and 12.7-15.1 g 100 g^{-1} respectively) was determined by Saikia et al. (1999). The fat content they reported was about 50% lower than determined in our study.

Content of amino acids

The content of amino acids is presented in Table 2. The dominant amino acids were glutamic acid (21.7-29.2 mg g^{-1}) and aspartic acid (18.0-23.1 mg g^{-1}). Methionine and cysteine composed the lowest percentage of all amino acids. Runner bean was characterized by the lowest amino acids content. The high-

Table 1

Content of dry mass, protein, fat and fatty acids, soluble sugars in legumes

Specification	Small bean (n = 5)	Dark red kidney bean (n = 5)	Cannellini bean (n = 5)	Runner bean (n = 5)	Pea (whole) (n = 5)
	mean ± SD	mean ± SD	mean ± SD	mean ± SD	mean ± SD
Dry mass (g 100 g^{-1})	$86.1^{a} \pm 1.1$	$87.1^{a} \pm 1.6$	$86.4^{a} \pm 1.5$	$84.0^{a} \pm 6.5$	$86.8^{a} \pm 1.2$
Sugars, soluble (g 100 g^{-1})	$4.28^{a} \pm 1.26$	$4.84^{a} \pm 0.68$	$7.23^{b} \pm 1.11$	$7.86^{b} \pm 1.49$	$4.7^{a} \pm 1.81$
Reducing sugars (g 100 g^{-1})	$0.392^{a} \pm 0.065$	$0.503^{ab} \pm 0.068$	$0.420^{a} \pm 0.077$	$0.487^{a} \pm 0.084$	$0.653^{b} \pm 0.149$
Fat (g 100 g^{-1})	$1.32^{a} \pm 0.15$	$1.22^{a} \pm 0.13$	$1.87^{b} \pm 0.19$	$1.95^{b} \pm 0.35$	$1.07^{a} \pm 0.27$
Oleic acid C18:1n9 (g 100 g^{-1})	$0.105^{a} \pm 0.030$	$0.121^{a} \pm 0.007$	$0.204^{ab} \pm 0.092$	$0.170^{a} \pm 0.035$	$0.237^{b} \pm 0.025$
Linoleic acid C18:2n6 (g 100 g^{-1})	$0.338^{a} \pm 0.034$	$0.315^{a} \pm 0.033$	$0.727^{c} \pm 0.175$	$0.734^{c} \pm 0.109$	$0.479^{b} \pm 0.048$
α-linolenic acid C18:3n3 (g 100 g^{-1})	$0.583^{b} \pm 0.030$	$0.556^{b} \pm 0.040$	$0.512^{b} \pm 0.108$	$0.694^{b} \pm 0.127$	$0.133^{a} \pm 0.074$
Total saturated (g 100 g^{-1})	$0.253^{a} \pm 0.028$	$0.196^{a} \pm 0.021$	$0.372^{a} \pm 0.037$	$0.313^{a} \pm 0.055$	$0.187^{a} \pm 0.047$
Total monosaturated (g 100 g^{-1})	$0.144^{a} \pm 0.016$	$0.157^{a} \pm 0.017$	$0.247^{b} \pm 0.025$	$0.210^{b} \pm 0.037$	$0.265^{b} \pm 0.067$
Total polyunsaturated (g 100 g^{-1})	$0.921^{b} \pm 0.103$	$0.872^{b} \pm 0.094$	$1.242^{c} \pm 0.124$	$1.429^{c} \pm 0.252$	$0.613^{a} \pm 0.155$
Total n7 (g 100 g^{-1})	$0.035^{b} \pm 0.009$	$0.033^{b} \pm 0.004$	$0.039^{b} \pm 0.002$	$0.038^{b} \pm 0.003$	$0.009^{a} \pm 0.002$
Total n9 (g 100 g^{-1})	$0.107^{a} \pm 0.030$	$0.123^{a} \pm 0.007$	$0.207^{b} \pm 0.092$	$0.172^{ab} \pm 0.035$	$0.242^{b} \pm 0.025$
Total n6 (g 100 g^{-1})	$0.339^{a} \pm 0.034$	$0.315^{a} \pm 0.034$	$0.727^{c} \pm 0.175$	$0.734^{c} \pm 0.109$	$0.479^{b} \pm 0.048$
Total n3 (g 100 g^{-1})	$0.583^{b} \pm 0.030$	$0.556^{b} \pm 0.030$	$0.512^{b} \pm 0.108$	$0.694^{b} \pm 0.127$	$0.133^{a} \pm 0.074$
Protein (g 100 g^{-1})	$19.49^{a} \pm 4.6$	$22.5^{a} \pm 1.0$	$19.0^{a} \pm 1.0$	$17.9^{a} \pm 4.0$	$19.6^{a} \pm 1.8$
Fe (mg 100 g^{-1})	$5.316^{c} \pm 0.777$	$4.980^{bc} \pm 0.474$	$4.266^{b} \pm 0.242$	$4.629^{bc} \pm 0.673$	$3.253^{a} \pm 0.336$
Cu (mg 100 g^{-1})	$0.503^{c} \pm 0.128$	$0.42^{bc} \pm 0.059$	$0.207^{a} \pm 0.081$	$0.256^{ab} \pm 0.104$	$0.402^{bc} \pm 0.132$
Zn (mg 100 g^{-1})	$2.144^{a} \pm 0.271$	$2.433^{a} \pm 0.237$	$2.033^{a} \pm 0.185$	$1.942^{a} \pm 0.175$	$2.424^{a} \pm 0.676$
Ca (mg 100 g^{-1})	$175.\ 4^{b} \pm 57.3$	$96.5^{a} \pm 26.6$	$96.7^{a} \pm 31.8$	$136.3^{ab} \pm 31.7$	$78.7^{a} \pm 27.4$
Mg (mg 100 g^{-1})	$132.0^{ab} \pm 21.7$	$108.9^{a} \pm 17.6$	$132.3^{ab} \pm 30.5$	$152.9^{b} \pm 14.8$	$108.0^{a} \pm 28.6$
Na (mg 100 g^{-1})	$10.0^{a} \pm 5.3$	$7.2^{a} \pm 3.9$	$7.1^{a} \pm 2.5$	$15.0^{a} \pm 12.1$	$9.7^{a} \pm 4.7$
K (mg 100 g^{-1})	$1122.9^{ab} \pm 189.2$	$1082.\ 5^{ab} \pm 132.7$	$1322.1^{b} \pm 328.8$	$1329.0^{b} \pm 195.3$	$898.0^{a} \pm 253.0$

a,b,c – the same letters in rows mean homogeneous group

Table 2

Content of amino acids in legumes compared to the FAO/WHO/UNU pattern of essential amino acids required by adults (mg g^{-1})

Amino acid	Small bean (n = 5)		Dark red kidney bean (n = 5)		Cannellini bean (n = 5)		Runner bean (n = 5)		Pea (whole) (n = 5)	
	mean ± SD	% of protein standard	mean ± SD	% of protein standard	mean ± SD	% of protein standard	mean ± SD	% of protein standard	mean ± SD	% of protein standard
Thr	$8.79^{a} \pm 2.53$	122.8	$7.66^{a} \pm 1.75$	92.5	$8.12^{a} \pm 1.30$	115.6	$7.50^{a} \pm 0.38$	113.8	$7.58^{a} \pm 0.54$	105.0
Met	$2.09^{b} \pm 0.27$	**62.4**	$2.03^{b} \pm 0.20$	**54.0**	$1.85^{ab} \pm 0.14$	**63.5**	$1.74^{a} \pm 0.11$	**66.6**	$1.76^{a} \pm 0.09$	**64.7**
Cys	$1.18^{a} \pm 0.33$		$1.26^{ab} \pm 0.27$		$1.43^{ab} \pm 0.26$		$1.49^{ab} \pm 0.14$		$1.67^{b} \pm 0.08$	
Ile	$6.88^{a} \pm 1.93$	116.9	$7.78^{a} \pm 0.51$	113.8	$6.20^{a} \pm 0.41$	106.9	$6.38^{a} \pm 0.74$	117.4	$6.22^{a} \pm 1.58$	104.4
Leu	$13.51^{ab} \pm 2.66$	97.6	$14.61^{b} \pm 1.24$	90.8	$12.04^{a} \pm 0.66$	88.2	$11.63^{a} \pm 1.45$	90.9	$12.92^{ab} \pm 0.67$	92.1
Val	$8.35^{a} \pm 2.02$	114.0	$9.32^{a} \pm 0.90$	109.4	$8.20^{a} \pm 0.31$	113.6	$7.80^{a} \pm 0.86$	115.2	$7.80^{a} \pm 0.84$	107.7
Lys	$12.37^{ab} \pm 1.93$	101.7	$13.23^{ab} \pm 0.96$	93.4	$12.18^{ab} \pm 0.84$	101.6	$11.72^{a} \pm 0.94$	104.2	$13.99^{b} \pm 0.45$	113.4
Phe	$9.79^{ab} \pm 1.80$	122.0	$10.11^{b} \pm 0.73$	108.5	$8.33^{a} \pm 0.64$	105.8	$7.97^{a} \pm 1.21$	107.2	$8.88^{ab} \pm 0.32$	114.7
Tyr	$6.32^{ab} \pm 1.24$		$6.56^{b} \pm 0.61$		$5.44^{ab} \pm 0.59$		$5.12^{a} \pm 0.91$		$6.47^{ab} \pm 0.42$	
Asp	$21.05^{abc} \pm 3.03$		$23.12^{c} \pm 2.16$		$18.51^{ab} \pm 1.29$		$18.00^{a} \pm 1.83$		$21.36^{bc} \pm 0.86$	
Ser	$11.192^{a} \pm 1.74$		$11.01^{a} \pm 2.35$		$10.49^{a} \pm 1.64$		$9.85^{a} \pm 0.82$		$10.08^{a} \pm 0.39$	
Glu	$25.27^{a} \pm 4.02$		$28.36^{b} \pm 3.22$		$22.61^{a} \pm 1.18$		$21.75^{a} \pm 2.27$		$29.23^{b} \pm 0.97$	
Pro	$6.88^{a} \pm 1.42$		$7.65^{a} \pm 0.94$		$7.24^{a} \pm 1.62$		$6.81^{a} \pm 0.64$		$8.17^{a} \pm 0.35$	
Gly	$6.86^{ab} \pm 0.79$		$7.29^{bc} \pm 0.49$		$6.49^{ab} \pm 0.47$		$6.38^{a} \pm 0.45$		$8.01^{c} \pm 0.44$	
Ala	$7.32^{ab} \pm 0.86$		$7.61^{ab} \pm 0.49$		$7.21^{ab} \pm 0.29$		$6.93^{a} \pm 0.42$		$8.11^{b} \pm 0.46$	
His	$5.40^{a} \pm 0.78$		$5.72^{a} \pm 0.53$		$5.10^{a} \pm 0.46$		$5.11^{a} \pm 0.55$		$4.93^{a} \pm 0.28$	
Arg	$13.31^{a} \pm 2.68$		$13.74^{a} \pm 1.94$		$11.71^{a} \pm 0.84$		$12.41^{a} \pm 1.81$		$19.18^{b} \pm 2.13$	
Total	$166.5^{abc} \pm 27.0$		$177.0^{c} \pm 15.35$		$153.2^{ab} \pm 11.5$		$148.6^{a} \pm 13.3$		$176.6^{bc} \pm 6.7$	

a,b,c – the same letters in rows mean homogeneous group est amounts of aspartic acid, leucine, phenylalanine and tyrosine were found in dark red kidney bean, but the highest amounts of glutamic acid, glycine, alanine, cysteine, lysine and arginine were found in peeled pea. The amino acid profile of legumes was compared to the pattern of essential amino acid (EAA) required for adults according to the Food and Agricultural Organization/World Health Organization/United Nations University (FAO/WHO/UNU) (FAO/WHO/UNU 1985) – Table 2. All investigated pulses were poor in methionine and cysteine as well as in leucine. Additionally, dark red kidney bean was characterized by a low lysine content in comparison to the FAO/WHO standard. Similar results were determined by Khalil, Khan (1995) and Bhagya et al. (2009).

Content of fatty acids

The mean content of fatty acids and groups of fatty acids is presented in Table 1. Pulses were characterized by the following content of fatty acids: α – linoleic acid varied from 0.13 g 100 g^{-1} in peeled pea to 0.69 g 100 g^{-1} in runner bean; linolic acid varied from 0.32 g 100 g^{-1} in dark red kidney bean to 0.73 g 100 g^{-1} in runner bean; oleic acid varied from 0.11 g 100 g^{-1} in small bean to 0.24 g 100 g^{-1} in peeled pea. The residual content of fatty acids varied from 0.01 to 0.03 g 100 g^{-1}. More than half of all the determined fatty acids were polyunsaturated. They were mainly found in runner bean and cannellini bean (1.4 and 1.2 g 100 g^{-1} respectively). The highest amounts of monounsaturated fatty acids were determined in pea, cannellini bean and runner bean (0.21-0.27 g 100 g^{-1}). The content of saturated fatty acids varied from 0.19 g 100 g^{-1} in peeled pea to 0.37 g 100 g^{-1} in cannellini bean, and did not differ statistically. The dominant unsaturated fatty acids in dark red kidney bean and small bean were acids from the n-3 group, while acids from group n-6 were prevalent in pea, runner bean and cannellini bean. Linoleic acid (n-6) and α-linolenic acid (n-3) are widely distributed in plant oils. In the body, essential fatty acids are primarily used to produce hormone-like substances that regulate a wide range of functions, including blood pressure, blood clotting, blood lipid levels, immune response and the inflammation response to infection of an injury. Over the last 50 years, the omega-6 to omega-3 ratio in America and western Europe has changed from 2:1 to 10-20:1. Now, a diet includes huge amounts of oils that are extracted from plants and used for cooking or in prepared foods. These oils (such as corn oil, sunflower oil, cottonseed oil, peanut oil, soybean oil) are primarily omega-6 ones. Eating too much omega-6 and too little omega-3 fatty acids causes clots and constricts arteries, which increases the risk of heart attacks, exacerbates swelling, worsens arthritis and aggravates the skin disease called psoriasis. It may block one's ability to respond to insulin, causing high insulin and blood sugar levels and obesity. In order to regain a a more healthful 4:1 ratio of omega-6s to omega-3, a diet should contain more seafood, whole grains, beans and other seeds (Hunter et al. 2010, Candela et al. 2011).

Content of macro- and microelements

The content of mineral compounds is presented in Table 1. The mean content of iron varied from 3.3 to 5.3 mg 100 g^{-1}. The lowest amount of this element was found in pea, but the highest one was determined in small bean. Runner bean, cannellini bean and dark red kidney bean were characterized by similar amounts of iron and did not differ statistically. In comparison to the results presented in this study, a lower iron content was determined by BHAGYA et al. (2009) as well as KHALIL, KHAN (1995). Chaudhary, SHARMA (2013) achieved similar results to ours, whereas SAIKIA et al. (1999) determined twice as much iron as shown in our study. In a meat-free diet, iron is the main mineral that can be taken in an inadequate amount. Iron has a direct influence on the immune system. Moreover, iron deficiency can lead to heart disorder or anaemia. It is claimed that the hem form of iron, found only in animal products, is more available than its non-hem form. Non-hem iron is found in vegetable food. The availability of non-hem iron can be improved by consuming products which are rich in vitamin C. Hence, regular consumption of pulses can help to counteract the shortage of iron in a diet.

The copper content differed in all the analyzed samples and varied from 0.21 mg 100 g^{-1} in cannellini bean to 0.50 mg 100 g^{-1} in small bean. The content of this element was similar in pea, runner bean and dark red kidney bean, and did not differ statistically.

The mean content of zinc varied from 1.9 mg 100 g^{-1} to 2.4 mg 100 g^{-1} in runner bean and dark red kidney bean, respectively, and it was lower than reported by other authors (BHAGYA et al. 2009, AKINYELE, SHOKUNBI 2015).

The mean content of calcium varied from 78.7 mg 100 g^{-1} to 175.4 mg 100 g^{-1}. The lowest amount of this mineral was found in pea, dark red kidney bean and cannellini bean. Statistically, the highest amount of calcium was determined in small bean. The determined values for calcium were higher than the results reported by CHAUDHARY, SHARMA (2013) as well as KHALIL, KHAN (1995), but similar to those demonstrated by BHAGYA et al. (2009). A higher calcium content in raw and cooked pulses was determined by SAIKIA et al. (1999).

The magnesium content in pulses was similar in almost all the analyzed plants and varied from 108.0 to 132.3 mg 100 g^{-1} in pea, small bean, dark red kidney bean, cannellini bean. Runner bean was characterized by the distinctly highest amount of this element (152.9 mg 100 g^{-1}). Similar values of magnesium were determined by KHAN et al. (2014) in dry seasons, whereas lower values (84.7 mg 100 g^{-1}) were found by BHAGYA et al. (2009).

The sodium content varied from 7.1 mg 100 g^{-1} in cannellini bean to mg 100 g^{-1} in runner bean. There were no statistical differences of the sodium content between the analyzed plants.

The potassium content was similar in all te samples and varied from 1082.5 mg 100 g^{-1} to 1329.0 mg 100 g^{-1} in all the kinds of beans. The content of this element was statistically lower in pea than in the other pulses, and equalled 898.0 mg 100 g^{-1}. A similar potassium content was determined by Khan et al. (2014) in dry seasons as well as by Bhagya et al. (2009). Khalil, Khan (1995) and Saikia et al. (1999) determined an approximately five-fold lower potassium content than demonstrated in this work.

CONCLUSIONS

All the analyzed pulses were characterized by a high nutritive value. They were mainly composed of proteins, including all amino acids with a beneficial composition of fatty acids. The identified amino acid profile indicates a sufficient quantity of lysine and a shortage of sulphuric acids. In order to obtain the best use of proteins, legumes should be eaten with cereal and dairy products. The ratio of omega-6 to omega-3 fatty acids was 1:2 to 4:1. This means that pulses may provide such quantities of omega-3 fatty acids that can balance off omega-6s fatty acids derived from other products. According to the present results, consumption of 200 g of pulses per day provides about 60 -100% of the recommended daily allowance of magnesium (350 mg per person), zinc (5 mg) and iron (M:8-11 mg/F:10-18 mg) and about 1/5 of the daily allowance of calcium.

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