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Nutritional quality of important food legumes

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Abstract

The proximate composition, mineral constituents and amino acid profile of four important legumes (chickpea, lentil, cowpea and green pea) were studied in order to evaluate their nutritional performance. Significant ($P < 0.05$) variations existed among the legumes with respect to their proximate composition, mineral constituent and amino acid profile. Lentil was found to be a good source of protein, while cowpea was good in ash among the grain legumes tested. All four types of legumes were also better suppliers of mineral matter, particularly potassium, phosphorus, calcium, copper, iron, and zinc. However, the concentrations of various mineral constituents was not in good nutritional balance. It was concluded that the four legumes tested were rich in lysine, leucine and arginine and can fulfil the essential amino acid requirement of human diet except for S-containing amino acids and tryptophan. In order to make good, the deficiency of certain essential amino acids in legume protein, they must be supplemented with other vegetables, meat and dairy products (e.g., Whey, yogurt).

Keywords: Legumes; Proximate analysis; Amino acids; Minerals; Chemical composition

1. Introduction

Protein-calorie malnutrition (PCM) is a major nutritional syndrome affecting more than 170 million preschool children and nursing mothers in developing Afro-Asian countries. The present trend in population growth indicates that the Protein gap may continue to increase in the future unless well-plane measures are taken to tackle the situation. Provision of adequate proteins of animal origin is difficult and expensive. An alternative for improving nutritional status of the people is to supplement the diet with plant proteins. Attention, therefore, has to be directed to the nutritional evaluation of proteins from plant species. Legumes (poor man's meat) play an important role in human nutrition since they are rich sources of protein, calories, certain minerals and vitamins (Deshpande, 1992). In Afro-Asian diets, legumes are the major contributors of protein and calories for economic and cultural reasons.

Food legumes are crops of the family Leguminosae also called Fabacae. They are mainly grown for their edible seeds, and thus are also named grain legumes. They occupy. large cropped areas worldwide. Grain legumes are used as pulse (dhal) with cereals, grown in both tropical and temperate regions of the globe. They enhances the protein content of cereal-based diets and may improve the nutritional status of the cereal-based diets. Cereal proteins are deficient in certain essential amino acids,particularly lysine (Amjad, Khalil, & Shah, 2003). On the other hand, legumes have been reported to contain adequate amounts of lysine, but are deficient in S-containing amino acids (methionine, cystine and cysteine) (Farzana & Khalil, 1999). Since the chemical composition of crops varies with crop cultivars, soil and

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climatic conditions of the area, it is imperative to study the chemical composition of some important food legumes (chickpea, cowpea, lentil and green pea). This study was, therefore, undertaken to analyze these legumes for their protein, amino acids and mineral contents in order to highlight their nutritional significance.

2. Materials and methods

2.1. Materials

Freshly harvested sun-dried seeds of four legumes (chickpea, cowpea, lentil and greenpea) were obtained from the Nuclear Institute of Food and Agriculture (NIFA), Peshawar, Pakistan. The seeds were dehulled and then ground to pass a 50-mesh screen. Powdered samples were preserved in air-tight bottles at room temperature. Sub-samples were dried in an oven at 100 ± 5 °C to constant weight, for moisture determination.

2.2. Proximate composition

Kjeldhal-N was determined and protein content was calculated by multiplying N by the factor 6.25 (Khalil & Manan, 1990). The other constituents, crude fat and ash, were estimated by the methods of A.O.A.C. (1990).

2.3. Minerals analysis

An acid digest was prepared by oxidizing each sub-sample with a nitric/perchloric acid (2:1) mixture. Aliquots were used to estimate Na and K by flame photometry, P by spectrophotometeric methods (Khalil & Manan, 1990) and Ca, Mg, Mn, Fe, Cu and Zn by atomic absorption spectrophotometry (A.O.A.C., 1990). Each sample was analysed thrice and the mean data are reported herein.

2.4. Amino acid analysis

Protein hydrolysate was prepared by treating 300-mg sample, in triplicate, from each cultivar with 6 N HC1 in an evacuated test tube for 24 h at 105 °C. After flash evaporation, the dried residue was dissolved in citrate buffer (pH 2.2). Aliquots were analysed in an LKB Biochrome automatic amino acid analyzer (model 4151) using a buffer system as described earlier (Zarkdas, Yu, Voldeng, & Minero-Amador, 1993). Methionine and cystine + cysteine were analysed separately after performic acid acid oxidation and subsequent hydrolysis with HCl (Khalil & Durani, 1990). Tryptophan was determined after alkali (NaOH) hydrolysis by a calorimetric method (Freidman & Finely, 1971).

2.5. Amino acid score

Essential amino acids score was calculated with reference to the FAO/WHO reference amino acid pattern (FAO/WHO, 1985).

$$\text{Amino acid score} = \frac{\text{Test amino acid} \times 100}{\text{Reference amino acid}}.$$

2.6. Statistical analysis

The data, based on three replicates, were subjected to analysis of variance by complete block design (Gomez & Gomez, 1984). Standard deviation of each individual nutrient of each legume mean was computed and variations among legumes were evaluated by least significance difference (LSD) at the 5% level of probability ($P = 0.05$).

3. Results and discussion

3.1. Proximate composition

The results in Table 1 show the comparative protein content of different legumes. It is evident that lentil contained the maximum amount of protein (26.1%), followed by green pea (24.9%) (Fig. 1). Among chickpea, cowpea, lentil and green pea, the content of ash was present in cowpea (4.2%). Similarly, the crude fat content was high in chickpea (5.2%), followed by cowpea (4.8%), lentil (3.2%) and green pea (1.5%). The result corresponds with those of Khalil (1994). Lentil was also proved by Jood, Bishnoi, and Sharma (1998) and Raghuvanshi, Shukla, and Sharma (1994) to be a good source of crude protein. Cowpea generally contains a high amount of ash (Khalil & Durani, 1989).

Table 1
Proximate composition of important grain legumes

Nutrients (g/100 g)	Chickpea	Cowpea	Lentil	Green pea
Moisture	7.3b ± 0.05	9.4a ± 0.07	9.3a ± 0.07	7.8b ± 0.07
Crude protein	24.0b ± 0.30	24.7ab ± 0.10	26.1a ± 0.09	24.9ab ± 0.03
Crude fat	5.2a ± 0.01	4.8a ± 0.07	3.2b ± 0.06	1.5c ± 0.04
Ash	3.6b ± 0.04	4.2a ± 0.05	2.8c ± 0.06	3.6b ± 0.04

Means in each column for each crop followed by the same letter are not significantly different ($P = 0.05$).
Each column contains means and S.D. of means.

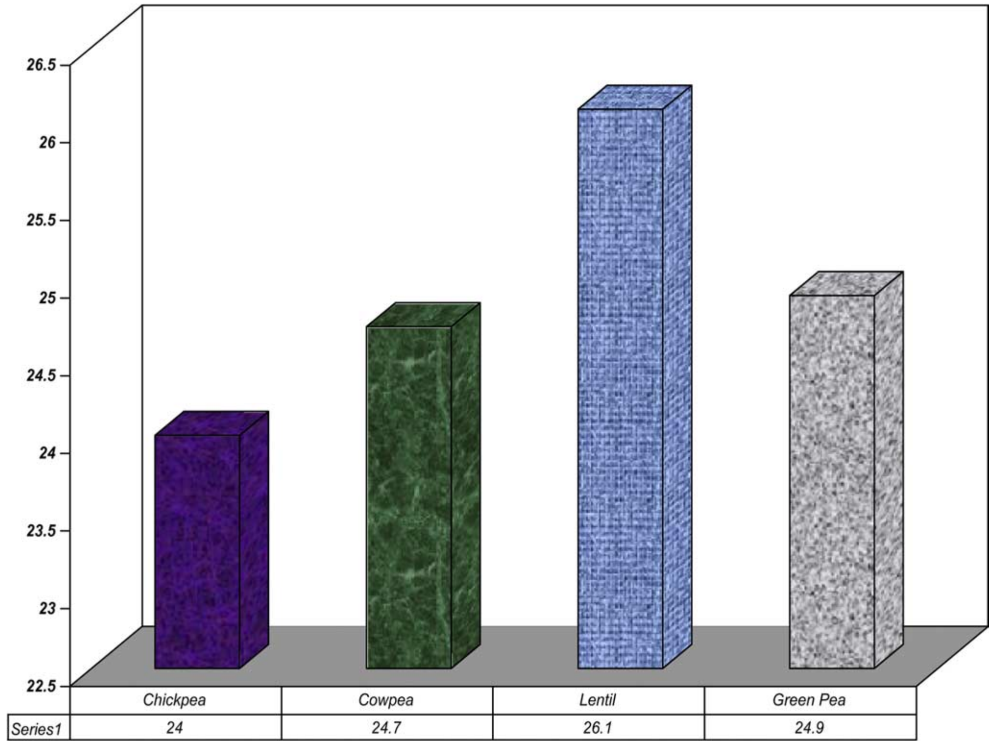

Fig. 1. Protein content (g/100 g) of important grain legumes.

3.2. Mineral content

Among the four legumes, cowpea had the highest concentrations of potassium, magnesium and phosphorus (Table 2). Sodium was found in an appreciable concentration in green pea. Chickpea contained good amounts of calcium, zinc and copper. These results revealed that legumes may provide sufficient amounts of minerals to meet the human mineral requirement (recommended dietary allowance, RDA) (NRC, 1980). However, excess of one mineral (e.g., K) may be antagonistic for others to be absorbed and utilized properly. For this reason, ratios of the mineral constituents are important for good nutrition. These ratios in legume seeds (Table 2) show imbalance between the potassium content and other minerals. Since plants have greater potash requirements than do animals and humans (Khalil, 1994), it may be difficult to screen the four legumes tested with potash concentrations less than or equal to 7.0 mg/g dry matter. Mineral supplementation can be used as an alternative approach to correct this imbalance. The mean Ca:P ratio in chickpea seed, being 0.7, reveals a high concentration of phosphorus compared to calcium. This ratio should not be less than 1.0. The results correspond those of Hadjipanayiotou and Economides (2001) and Ereifej, Al-Karaki, and Hammouri (2001).

Table 2
Mineral constituent of important grain legumes

Minerals (mg/100 g)	Chickpea	Cowpea	Lentil	Green pea
Sodium	101b ± 3.51	102ab ± 5.29	79c ± 2.65	111a ± 2.65
Potassium	1155b ± 5.00	1280a ± 8.62	874d ± 6.43	1021c ± 12.49
Phosphorus	25Ib ± 6.11	303a ± 7.94	294a ± 3.61	283a ± 3.00
Calcium	197a ± 3.61	176b ± 4.58	120c ± 6.24	110c ± 3.61
Iron	3.0a ± 0.20	2.6ab ± 0.20	3.1a ± 0.26	2.3b ± 0.05
Copper	11.6a ± 0.20	9.7b ± 0.20	9.9b ± 0.10	10.0b ± 0.40
Zinc	6.8a ± 0.26	5.1a ± 0.20	4.4a ± 0.20	3.2a ± 0.56
Manganese	1.9a ± 0.10	1.7a ± 0.04	1.6a ± 0.03	2.2a ± 0.02
Magnesium	4.6ab ± 0.04	4.8a ± 0.10	4.5b ± 0.04	4.2c ± 0.04
Na:K ratio	0.09	0.08	0.09	0.10
Ca:P ratio	0.78	0.59	0.41	0.39

Means in each column for each crop followed by the same letter are not significantly different ($P = 0.05$).
Each column contains mean and S.D. of mean.

Table 3
Amino acid composition of important grain legumes

Amino acids (% of protein)	Chickpea	Cowpea	Lentil	Green pea
Arginine	8.3a ± 0.21	7.5c ± 0.04	7.8b ± 0.03	7.2d ± 0.04
Histidine	3.0a ± 0.03	3.1a ± 0.03	2.2c ± 0.05	2.4b ± 0.05
Isoleucine	4.8a ± 0.03	4.5b ± 0.03	4.1b ± 0.05	4.5a ± 0.06
Leucine	8.7a ± 0.03	7.7b ± 0.08	7.8b ± 0.05	7.4b ± 0.05
Lysine	7.2b ± 0.03	7.5b ± 0.04	7.0b ± 0.03	8.1a ± 0.07
Methionine	1.1b ± 0.04	2.2a ± 0.04	0.8c ± 0.02	1.1b ± 0.03
Phenylalanine	5.5b ± 0.04	7.5a ± 0.06	5.0b ± 0.12	5.2b ± 0.04
Threonine	3.1b ± 0.04	3.8a ± 0.05	3.5a ± 0.04	3.8a ± 0.05
Tryptophan	0.9a ± 0.02	0.7a ± 0.02	0.7a ± 0.03	0.8a ± 0.02
Valine	4.6a ± 0.03	5.0a ± 0.06	5.0a ± 0.05	5.0a ± 0.09
Total	47.2	49.5	43.9	45.5
Alanine	4.97a ± 0.03	4.2b ± 0.03	4.2b ± 0.04	5.2a ± 0.04
Aspartic acid	11.0b ± 0.04	10.8b ± 0.08	11.8a ± 0.08	11.0b ± 0.06
Cystine	0.6c ± 0.06	0.5c ± 0.03	0.9b ± 0.04	1.8a ± 0.03
Glutamic acid	17.3bb ± 0.08	17.2b ± 0.06	21.5a ± 0.07	17.5b ± 0.06
Glyine	3.7b ± 0.03	3.8b ± 0.01	3.6b ± 0.05	4.5a ± 0.01
Proline	3.8a ± 0.05	4.0a ± 0.13	3.5b ± 0.03	3.8a ± 0.03
Serine	3.7c ± 0.02	4.5b ± 0.06	5.2a ± 0.05	5.1a ± 0.54
Tyrosine	2.8c ± 0.06	3.0bc ± 0.05	32a ± 0.06	3.7a ± 0.03
Total	47.7	48.0	53.9	52.9
E:NE amino acid ratio	0.99	1.03	0.81	0.86

Means in each column for each crop followed by the same letter are not significantly different ($P = 0.05$).
Each column contains mean and S.D. of mean.

3.3. Amino acid profile

The amino acid composition of the four legumes (chickpea, cowpea, lentil and green pea) (Table 3) indicated little variation in the contents of total essential and non-essential amino acids. However, significant ($P < 0.05$) variation existed in the individual amino acid contents, particularly for arginine, histidine and methionine. The arginine contents varied from 7.2% of protein in green pea to 8.3% of protein in chickpea. Among the four legumes, lysine, alanine, cystine and tyrosine were found to be rich in green pea, while phenylalanine and serine were found in appreciable amounts in lentil among the different legumes tested. Cowpea was found high in methionine and threonine. Glutamic acid and aspartic acid were found to be major non-essential amino acids in the sample tested. The total essential amino acids were maximum in cowpea, while maximum total non-essential amino acid was found in lentil (Fig. 2), among the tested legumes. The results are in fair agreement with those reported by Bhatty, Gilani, and Nagra (2000) and Hussain and Basahy (1998).

3.4. Nutritional quality of proteins

The nutritional qualities of chickpea, cowpea, lentil and green pea protein were assessed. Essential amino acid score was computed with reference to the FAO/WHO (1985) standard amino acid profile established for humans. The data (Table 4) indicated that all essential amino acids except S-containing and tryptophan were present in excessive amounts in all the cultivars tested. S-containing amino acids were the most limiting amino acids in chickpea; in contrast, tryptophan was most deficient in cowpea, lentil and greenpea.

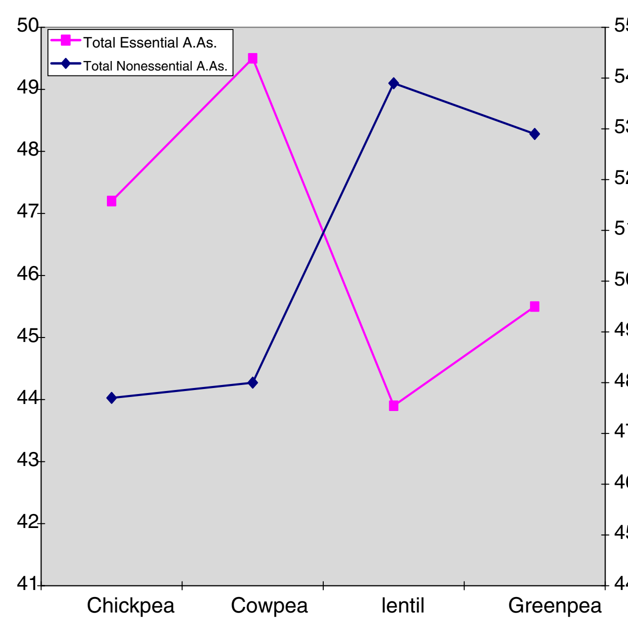

Fig. 2. Total essential and non-essential amino acids (% of protein) of grain legumes.

Table 4
Amino acid score of important grain legumes

Amino acids	Reference pattern	Chickpea	Cowpea	Lentil	Green pea
Histidine	1.9	158	163	116	126
Lysine	5.8	124	129	121	140
Leucine	6.6	132	117	118	112
Isoleucine	2.8	171	161	146	161
Methionine + cystine	2.5	68	108	68	116
Phenylalanine + tyrosine	6.3	132	167	130	141
Threonine	3.4	91	112	88	111
Tryptophan	1.1	82	64	64	55
Valine	3.5	131	143	143	143
Limiting amino acid[a]	–	S	T	T	T

FAO/WHO (1985) amino acid reference pattern of protein for children (2–5 years old) diet. Values are % of protein. Each amino acid in the reference pattern was presumed to score a value = 100. Values for each cultivar are expressed relatively to the reference pattern.
[a] S, sulphur containing amino acids (methionine + cystine); T, tryptophan and Th, threonine.

4. Recommendation

Malnutrition is currently widespread in many areas of the world. The most serious nutritional problem is protein calorie malnutrition (PEM), especially among children in the developing countries. The lower income group of the population is particularly vulnerable, because of its low purchasing power and because the conventional sources of protein (meat and milk) are usually costly and thus beyond the purchasing power of this group. Attention, therefore, must be focussed on the cheap, but nutritious plant protein sources, such as pulses and cereals. It is advisable to enhance the protein content of easily available and accessible plant protein sources (especially legumes) to improve the nutritional status of the low-income groups of the population. The nutritional significance of the legumes must be highlighted by mass media (press, radio and T.V.). In order to improve the protein quality of leguminous seeds, their consumption should be combined with cereals or other protein sources (i.e. milk and milk products, egg and meat).

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