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Nutritive Value of Central American Beans. IV. The Essential Amino Acid Content of Samples of Black Beans, Red Beans, Rice Beans, and Cowpeas of Guatemala [a]

R. BRESSANI, L. G. ELIAS, AND D. A. NAVARRETE
Division of Agricultural and Food Chemistry, Institute of Nutrition of Central America and Panama (INCAP), Guatemala, C.A.

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SUMMARY

The rice bean *(Phaseolus calcaratus)*, cowpea *(Vigna sinensis)*, red bean, and three black bean *(Phaseolus vulgaris)* samples grown in Guatemala, were found to be fairly similar in chemical composition. Average percentage values were: moisture 14.5, protein 22.3, ether extract 1.3, ash 3.5, crude fiber 6.0, and carbohydrate 52.4. The range in amino acid content, expressed as mg of amino acid per gram of nitrogen, was: arginine 356–528, histidine 159–232, isoleucine 143–339, leucine 189–260, lysine 322–544, total sulfur-containing amino acids 80–94, phenylalanine plus tyrosine 362–471, tryptophan 52–73, threonine 215–348, and valine 191–383. The cowpea sample was higher in lysine; the rice bean and red bean samples were higher in tryptophan. The isoleucine and valine contents were lower, and the leucine higher, in the red beans than in the other samples. When compared with the amino acid pattern of the FAO Reference Protein, methionine plus cystine was the most-limiting amino acid, and leucine and tryptophan respectively the second- and third-most limiting. All the samples contained high amounts of lysine, making beans a good source of this amino acid.

Among vegetable foods, legume seeds represent a rich source of protein, although research on their use and dietary value has been somewhat neglected. They not only contain a relatively large amount of protein but also have an essential amino acid pattern that complements that of corn and other cereal grains (FAO, 1954). Since, in most of the Central-American countries, beans of the *Phaseolus vulgaris* variety provide 20–30% of the protein in the rural diet (Tandon *et al.*, 1957), the quality of their protein is of considerable practical importance. The chemical composition and the lysine, methionine, and tryptophan content of some varieties of beans and other leguminous seeds (Bressani *et al.*, 1954, 1960; Jelliffe *et al.*, 1956) have been studied previously. This paper reports on the essential amino acid content of additional samples.

EXPERIMENTAL METHODS

The leguminous seeds studied were rice beans *(Phaseolus calcaratus)* grown in the highlands of Guatemala and obtained from the local market in Guatemala City, cowpeas *(Vigna sinensis)* and red beans *(Phaseolus vulgaris)* also from a market in Guatemala City, and three black bean samples *(Phaseolus vulgaris)* respectively from markets in the highland towns of San Pedro Ayampuc, Tecpán, and Parramos.

Five-pound samples were brought to the laboratory, ground to pass 60 mesh, and stored at 4°C pending analysis. The moisture, nitrogen, ether extract and ash content were determined by A.O.A.C. (1945) methods. The essential amino acid content was measured microbiologically by hydrolizing 1-g samples 8 hr in the autoclave with 6*N* HCl or 4*N* NaOH. The lysine, methionine, leucine, isoleucine, arginine, cystine, phenylalanine, and tyrosine contents were determined with Difco media (Difco Laboratories, Detroit, Michigan)

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Table 1. Proximate chemical composition of the six bean samples (per cent).

Sample	Moisture	Protein	Ether extract	Ash	Crude fiber	Carbohydrates [a]
Cowpea	14.2	24.2	1.2	3.2	6.2	51.0
Rice bean	13.5	20.7	0.7	3.8	7.2	54.1
Red bean	14.1	22.2	1.0	4.0	6.9	51.8
Black bean (Parramos)	15.7	22.8	1.8	3.4	5.3	51.0
Black bean (San Pedro Ayampuc)	15.5	22.6	1.5	3.3	4.8	52.3
Black bean (Tecpán)	14.5	21.4	1.8	3.2	5.4	53.7
Average	14.5	22.3	1.3	3.5	6.0	52.4

[a] Values obtained by difference (100 – % H_2O – % protein – % ether extract – % ash – % crude fiber).

and *Leuconostoc mesenteroides* P-60. The valine and histidine were determined using the organism and the media recommended by Steele *et al.* (1949). The threonine assay also employed the medium of Steele *et al.* (1949) with *Streptococcus faecalis* 8043 as the microorganism. Tryptophan was determined with Difco media and *Lactobacillus arabinosus* 17-5.

RESULTS

Table 1 shows the proximate chemical composition of the six samples. The four *Phaseolus vulgaris* samples contained a similar quantity of protein, the cowpea sample a slightly higher amount, and the rice beans the least. All samples had a similar ash content, whereas crude fiber was higher in the red bean, rice bean, and cowpea samples than in the black beans; the reverse was found for the ether extract content.

When the essential amino acid composition of the six legume seeds is expressed on a percentage basis, the common black beans and the cowpea showed a higher percentage of tryptophan than the rice bean. The lysine content of the rice bean samples was slightly higher than that of the other samples, particularly that of the red bean, which had the lowest amount. The total sulfur-containing amino acids were higher in the cowpea, red bean, and rice bean samples. In all samples but the red bean, the isoleucine content was higher than that of leucine.

Differences in essential amino acid content among the samples became more evident when expressed on the basis of mg of amino acid/g of nitrogen (Table 2). The rice bean sample was highest in lysine, and the red beans and Parramos beans contained the most tryptophan. Methionine and cystine contents were similar in all the samples. The red bean samples had the lowest isoleucine and valine content. Also included in the table is the amino acid pattern of the FAO Reference Protein for comparison with that of the amino acid composition of the samples studied.

DISCUSSION

Leguminous seeds, particularly beans, have often been mentioned as good foods to correct the amino acid deficiencies of cereals. For most of them, however, relatively little of the biological work essential for their

Table 2. Essential amino acid content in the six bean samples (mg A.A./g nitrogen).

Amino Acid	Cowpea	Rice bean	Red bean	Black bean (Parramos)	Black bean (San Pedro Ayampuc)	Black bean (Tecpán)	FAO Protein Reference
Arginine	398	470	528	370	356	511	.....
Histidine	193	215	232	185	159	176	.....
Isoleucine	291	339	143	331	317	309	270
Leucine	211	260	219	202	189	223	306
Lysine	461	545	322	486	490	523	270
Methionine	71	77	70	64	66	71	270
Cystine	15	17	17	16	17	14	
Phenylalanine	302	365	390	320	320	330	360
Tyrosine	60	52	81	67	61	58	
Tryptophan	59	52	73	71	66	67	90
Threonine	215	287	343	348	277	304	180
Valine	328	371	191	383	354	342	270

efficient use in human feeding has been done. The leguminous seeds in this study had a relatively high essential amino acid content, but, compared with the FAO Reference Protein (FAO, 1957), they were deficient in methionine, cystine, leucine, and tryptophan.

The sulfur amino acids were the first-limiting, with a protein score of around 32%. Other investigators have also reported the marked deficiency of methionine in the leguminous seeds (Baptist, 1954; Cerighelli *et al.*, 1960; Jaffe, 1950). The second-limiting amino acid was leucine, with an average score of 72% for the samples. These results are important since the average ratio of leucine to isoleucine in all the samples was 1.0 : 1.33, compared to a leucine to isoleucine ratio in the FAO Reference Protein of 1.0 : 0.68; red beans were an exception, with a ratio similar to that in the FAO Reference Protein. The samples also contained a relatively high proportion of valine, which could cause an imbalance of the type reported by Harper and Kumta (1959) between isoleucine, valine, and leucine. In addition, it would be useful to know whether leucine is, in fact, the second-limiting amino acid, and the effect of correcting the disproportion of this amino acid in relation to isoleucine and valine. From a practical point of view, however, the low leucine content of beans may be an advantage for populations that consume tortillas, since the leucine content of corn is relatively high (Bressani and Mertz, 1958).

By comparison with the amino acid pattern of the FAO Reference Protein (FAO, 1957), tryptophan is the third-limiting amino acid, averaging 72% for all samples, but further study is necessary to determine if a true deficiency exists. At least, the tryptophan deficiency is not important as a niacin precursor in beans, since Bressani *et al.* (1954) and Cravioto *et al.* (1945) reported that, like most leguminous seeds, they are good sources of niacin.

The lysine content was relatively high in all the samples studied, about twice that of the amino acid pattern of the FAO Reference Protein (FAO, 1957). Therefore, beans should complement the lysine deficiency in cereal protein. Further study is needed to determine the optimum combination of beans and cereal grains, and the degree of improvement in the protein quality obtained in the final combination (Bressani *et al.*, 1961).

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