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The Nutritive Value of Eight Varieties of Cowpea (Vigna sinensis)[a, b]

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SUMMARY

Samples of eight varieties of cowpea, both raw and cooked, were analyzed for their chemical composition and amino acid content by microbiological methods and were also subjected to biological trials with rats in order to determine their nutritive value. Cooking caused losses as follows: 9.2% nitrogen, 17.4% crude fiber, 62% thiamine, 52% riboflavin, and 45% niacin. With the possible exception of tryptophan, the variation for amino acids was small among all the samples, both cooked and raw, and there was no difference in ether extract and ash. The animal experiments showed marked differences in protein value among the eight samples, even though essential amino acid composition indicated only slight differences. These differences are probably due to variation in amino acid availability. The protein efficiency ratio was higher in the cowpea samples than in the beans. Since cowpeas have a higher nutritive value than common beans, as confirmed in this study, and can be grown under many environmental conditions with higher yields, their use in human feeding should be recommended in developing areas of the world having protein in low quantity and quality.

Dietary surveys in the Central American countries have shown that corn (*Zea mays*) and beans (*Phaseolus vulgaris*) are the two most important sources of protein in rural diets (Flores, 1961). From the nutritional point of view, cereal grains not only are low in total protein but are deficient in some of the essential amino acids, particularly lysine. Leguminous seeds, such as cowpeas (*Vigna sinensis*), could supply the limiting amino acid in corn protein as well as replace black beans, since the two are very much alike in appearance, texture, and flavor; they could also be a better supplement for cereal-based diets.

The essential amino acid content of the cowpea has been studied by several investigators (Bressani *et al.*, 1961; Busson *et al.*, 1959; Jaffé, 1949; Orr and Watt, 1957) and the results indicated that methionine is the most limiting amino acid. The cowpea, like other leguminous seeds, contains a trypsin inhibitor that has been the object of several studies. According to Sohonie and Bhandarker (1954), the cowpea trypsin inhibitor can be destroyed by heating 1 hr at 100°C. Jaffé (1950a), from studies of the relationship between the digestibility of cowpeas and its trypsin inhibitor, reported that heating in the autoclave was sufficient to destroy the inhibitor, but that this treatment did not improve the coefficient of digestibility. Similar studies have been reported by Borchers and Ackerson (1950).

Biological studies have also been undertaken by several investigators (Borchers and Ackerson, 1950; Chavez *et al.*, 1952; Finks *et al.*, 1922; Jaffé, 1949; Sherwood *et al.*, 1954), who reported that cowpea protein is limited in methionine but is a good source of lysine. The present study was designed to obtain additional chemical and biological data on the cowpea.

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[c] From a thesis by R. Colindres for a degree in Chemistry and Pharmacy from the University of Honduras, Tegucigalpa, Honduras.

MATERIALS AND METHODS

Samples and analytical procedures. Eight sample varieties of cowpea from the United States that had been introduced into Guatemala in 1959, were used: 1) Calico Crowder, 2) Brown Eye Crowder.

3) Black Eye Peas, 4) Blue Goose, 5) Bunch Purple Hull, 6) Black Crowder, 7) Lady Peas, and 8) Dixie Lee Peas. The samples were certified seed obtained from a commercial store. They were harvested from experimental plots in the lowlands of Guatemala, of highly fertile soils with high rainfall. Ten pounds of each variety were stored at 4°C. Each sample was divided into two parts; 450 g were used for chemical analysis of the raw material, and the remaining quantity was cooked and used in biological trials with rats and for chemical analysis after cooking. About 7 lb of each variety were first soaked in sufficient water for about 2 hr; they were then covered completely with more water and cooked 10 min at 126°C in an autoclave at 15 lb pressure. The cooked samples were then dried by air at 88°C for 24 hr. The raw and cooked material of each variety was ground in a Wiley mill to pass 40-mesh. The ground samples were kept under refrigeration at 4°C until needed for chemical determinations and biological assays.

AOAC (1950) methods were used in the chemical analyses. Thiamine content was determined by the thiochrome method of Hennessy and Cerecedo (1939), and riboflavin by the fluorometric method of Hodson and Norris (1939). The lysine, methionine, leucine, isoleucine, arginine, cystine, phenylalanine, and tyrosine contents were obtained by using Difco media and *Leuconostoc mesenteroides* P-60. Used for the cystine and valine analysis were synthetic media as recommended by Steel *et al.* (1949); and the threonine content was found with synthetic media and *Streptococcus faecalis* as microorganisms. Tryptophan was determined with *Lactobacillus arabinosus* and Difco media.

Biological trials. To determine the nutritive value of the eight varieties of cowpea, 54 weanling rats of the Wistar strain, from INCAP's animal colony, were divided into groups of 3 males and 3 females each. Their weight was distributed so that the average initial weight of the groups did not differ by more than 1 g. The rats were kept in all-wire cages with raised screen bottoms. Food intake and weight gain were recorded every seven days for 28 days. Food and water were given *ad libitum.* Table 1 shows partial composition of the experimental diets. The control was a soybean diet having the same protein level. All diets were supplemented with 4% of salt mixture, 5% of cottonseed oil, 1% cod liver oil, cornstarch to make 100 g, and 4 ml of a vitamin solution (Manna and Hauge, 1953).

For the protein depletion-repletion experiment, adult rats, weighing 200 g, were fed a protein-free diet made of 86% cornstarch, 5% salt mixture, 5% cottonseed oil, 2% cod liver oil, and 4 ml of a complete vitamin solution (Manna and Hauge, 1953) until they lost 25% of their original weight. The animals were then distributed by weight into 9 groups of 3 males and 3 females each and fed experimental diets for 14 days. The diets were analyzed for nitrogen content in order to calculate their protein efficiency ratio (PER). A second rat experiment, using the procedure previously described, compared the growth-promoting value of five cowpea samples to that of cooked black beans fed at 10% protein level in the diet.

RESULTS

Table 2 shows the chemical composition of the cowpea samples before and after cooking. As can be seen, the cooked material showed 9.2% less nitrogen and 17.4% less crude fiber than the raw material, but there was no difference between the raw and cooked samples in the ether extract and

Table 1. Percentage composition of diets used in the biological trials.

Ingredients	Samples [a] 1	3	5	6	7	8	9	10	11
Cowpea	42.44	41.36	40.40	39.90	42.11	43.01	38.46	44.58	....
Soybean	....	....	....	....	....	....	....	....	20.00
Minerals [b]	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Cottonseed oil	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Cod liver oil [c]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Cornstarch	47.56	48.64	49.60	50.10	47.89	46.99	51.54	45.42	70.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Vitamin solution,[d] ml	4	4	4	4	4	4	4	4	4
% protein in diet	9.44	9.50	9.94	9.62	9.50	9.70	9.12	9.56	8.06

[a] No. 1 Calico Crowder, No. 3 Brown Eye Crowder, No. 5 Black Eye Peas, No. 6 Blue Goose, No. 7 Bunch Purple Hull, No. 8 Black Crowder, No. 9 Lady Peas, No. 10 Dixie Lee Peas, and No. 11 Soybean Flour (50% protein).

[b] Salt mixture, Hegsted, Nutritional Biochemical Corporation, Cleveland, Ohio.

[c] Mead Johnson, Evansville, Indiana.

[d] Manna and Hauge (1953).

Table 2. Nutrient content of eight varieties of cowpea.[a]

	Raw			Cooked		
Substance	Range	Av.	Std. dev.	Range	Av.	Std. dev.
Protein, g%	24.1–25.4	24.8	0.48	22.4–26.0	24.1	1.13
Ether extract, g%	1.1– 3.0	1.9	0.62	1.7– 2.1	1.9	0.14
Crude fiber, g%	5.0– 6.9	6.3	0.64	3.6– 6.3	5.2	0.87
Ash, g%	3.4– 3.9	3.6	0.17	3.2– 3.6	3.4	0.14
Thiamin, mg	0.41–0.99	0.74	0.22	0.22–0.39	0.28	0.05
Riboflavin, mg	0.29–0.76	0.42	0.14	0.12–0.36	0.20	0.10
Niacin, mg	2.51–3.23	2.81	0.26	1.40–1.69	1.55	0.10

[a] All values expressed on a 10% moisture basis.

ash content. The variation among the samples was not significant.

Table 2 also gives the thiamine, riboflavin, and niacin content of both groups of samples. It indicates that there were great variations in the vitamin content of both the raw and cooked samples. Furthermore, the cooking process caused a 62% loss of thiamine, a 52% loss of riboflavin, and a 45% loss of niacin.

Table 3 shows the essential amino acid content of the raw and cooked samples. With the possible exception of tryptophan, the variation for individual amino acids among all the samples was small. When individual amino acids in both raw and cooked cowpea samples were compared, only small differences were found.

The results in growth and PER from the first growth experiment, summarized in Table 4, indicated that the cowpea samples have different nutritive values. The weight gains varied from 53 to 26 g, and the PER from 2.30 to 1.42. The gain in weight was higher with the soybean diet than with any of the eight varieties of cowpea.

The second growth experiment, also presented in Table 4, showed that black beans (*Phaseolus vulgaris*) have a lower nutritive value than cowpea, as demonstrated by the lower growth and PER obtained with beans. In addition, the table shows the results obtained with adult rats, whose weight gains varied from 63 to 54 g in the 14-day experimental period. As in the previous experiments, soybean proved to be the best protein.

DISCUSSION

The chemical composition of the cowpea samples (*Vigna sinensis*) was found to be similar to that of beans (*Phaseolus vulgaris*), according to data presented by several workers in Latin America (Bressani *et al.*, 1954, 1961; Chavez *et al.*, 1952; Jaffé, 1950b; Tandon *et al.*, 1957). Other authors reported that riboflavin and niacin (De and Borai, 1949; De and Datta, 1951; Hoover, 1955; Jaffé, 1950b; Jenkins, 1954; Richardson *et al.*, 1950) showed the greatest variation among varieties.

The variation in essential amino acid content is smaller in cowpea than reported for beans (Bressani *et al.*, 1961). When the average of the essential amino acid content of the eight varieties of raw cowpea was compared with that of beans, it was found

Table 3. Essential amino acid content for eight varieties of cowpea.

	Raw (mg)			Cooked (mg)		
Amino acids[a]	Range	Av.	Std. dev.	Range	Av.	Std. dev.
Arginine	0.433–0.572	0.500	0.053	0.430–0.516	0.474	0.043
Histidine	0.169–0.236	0.213	0.019	0.176–0.256	0.217	0.026
Isoleucine	0.305–0.333	0.318	0.010	0.309–0.354	0.327	0.018
Leucine	0.434–0.543	0.484	0.031	0.427–0.541	0.497	0.036
Lysine	0.467–0.497	0.486	0.011	0.400–0.466	0.430	0.022
Methionine	0.074–0.082	0.079	0.010	0.074–0.091	0.079	0.006
Cystine	0.026–0.038	0.032	0.004	0.025–0.040	0.028	0.005
Phenylalanine	0.251–0.290	0.263	0.012	0.228–0.268	0.252	0.013
Threonine	0.242–0.281	0.251	0.013	0.228–0.255	0.239	0.009
Tyrosine	0.113–0.137	0.124	0.008	0.111–0.129	0.121	0.006
Tryptophan	0.058–0.082	0.068	0.010	0.058–0.084	0.068	0.010
Valine	0.252–0.368	0.314	0.033	0.251–0.375	0.302	0.018

[a] Amino acids expressed on g of amino acids/g of nitrogen.

Table 4. Results of biological tests with rats fed cooked cowpea protein.

Sample	Cowpea 1	2	3	4	5	6	7	8	Soybean flour
Growth experiment [a]									
Gain in weight	42	47	39	31	53	26	49	53	94
PER	1.79	2.18	1.90	1.54	2.29	1.42	2.30	2.16	3.55
Repletion experiment [b]									
Gain in weight	63	58	61	54	59	54	62	56	73
PER	2.44	2.35	2.51	2.20	2.38	2.14	2.64	2.23	3.11
Comparison between cowpea and black beans [c]									
Gain in weight	27	39	25	22	....	....	....	33	13
PER	1.33	1.49	1.21	1.06	....	....	....	1.47	0.71

[a] Average initial weight: 45 g.
[b] Average initial weight: 175 g.
[c] Average initial weight: 61 g.

that cowpea samples had more arginine, histidine, leucine, methionine, tyrosine, and valine, and less phenylalanine and threonine.

The cooking process affected the proximate chemical composition of the samples only slightly, but there was a significant loss in vitamin content. Similar results have been reported by several investigators, not only for beans but also for other leguminous seeds (Bressani *et al.*, 1954; Sherwood *et al.*, 1954).

Changes were small when the essential amino acid content of the raw cowpea was compared with that of the cooked samples. By comparing the essential amino acid composition of the cowpea samples with that of the FAO (1957) protein reference pattern, methionine was found to be the most limiting amino acid, while tryptophan and lysine were found in sufficient amounts. This is of practical importance if cowpea is to supplement corn protein efficiently, since it is well known that corn proteins are deficient in both lysine and tryptophan, and contain adequate amounts of methionine. Therefore, the proteins of the two staple foods should complement each other efficiently.

The results obtained with animals are interesting. Although the eight varieties showed only small differences in essential amino acid composition, the rat experiments indicated that there is a marked difference, probably due to variations in amino acid availability, among the eight samples tested. In general, the protein efficiency ratio was higher for the cowpea samples than for the beans. The highest protein efficiency ratio obtained with black beans by Bressani *et al.* (1963) was 1.20, whereas it was 0.71 in the present study. Richardson (1948) also found differences in nutritive value among cowpea samples he studied, while Chavez *et al.* (1952), using rats, reported a growth and PER equivalent to 82.9% of the nutritive value of pure casein.

Since cowpeas have a better nutritive value than common black beans and can be grown under wider environmental conditions, it would be desirable to learn whether they would have the same acceptance by undernourished populations in the Central American area if they were prepared like black and red beans. Previous studies (Bressani and Scrimshaw, 1961) have also indicated that cowpea protein complements corn protein efficiently, a factor of practical value for those areas where the human rural population is largely dependent upon corn protein for most of its protein needs.

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