Nutritional Values of Mixtures of Polished Rice, Red Kidney Beans, Chickpeas, and Soybeans[1]

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POLISHED RICE and red kidney beans are the most frequently used foodstuffs in the nutritionally inadequate diets of Puerto Ricans. The low intake and poor quality of the proteins in the *jíbaro* (country family) diet[2] has already been reported. A recent publication,[3] comparing the yearly per capita consumption of foodstuffs in Puerto Rico with some areas of the United States, showed that the consumption of milk, cheese, eggs, and meats was only 82, 16, 44, and 33.4 pounds, respectively, in Puerto Rico, these values being less than those for the areas of the continent studied.

Biological assay tests with polished rice[4] have shown that growth promotion in rats is not possible without supplementing this diet with protein and other factors. The inadequacy of phaseolin, the principal protein of the red kidney bean, has also been demonstrated.[5] Aside from other deficiencies that exist in the Puerto Rican dietary, it is certain that there is a minimum consumption of good quality protein.

The object of the experiments reported in this paper was to study the possible improvement of the protein quality of the rice and red kidney bean mixture by adding other readily available cheap foodstuffs. The results obtained with a growth method[6] are reported herein. The rat was used as the experimental animal.

EXPERIMENTAL METHODS

Albino rats, 23 days of age and of the Sprague-Dawley strain, equally divided as to sex and initial weight, were placed in individual

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3. S. L. Descartes, S. Díaz Pacheco, and J. P. Nogueras, Food consumption studies in Puerto Rico. Bul. No. 59, Agricultural Experiment Station, Río Piedras, Puerto Rico, 1941.

4. M. C. Kik, Nutritive studies of rice and its by-products. Bul. No. 416, Agricultural Experiment Station, Fayetteville, Arkansas, 1942.

5. C. O. Johns and J. A. Finks, Studies in Nutrition. II. Role of cystine in nutrition as exemplified by nutrition experiments with proteins of the navy bean, *Phaseolus vulgaris*. J.Biol.Chem., **41**:379, 1920.

6. T. B. Osborne, L. B. Mendel, and E. L. Ferry, A method of expressing numerically the growth promoting value of proteins. J.Biol.Chem., **37**:223–229, 1919.

cages and fed, *ad libitum*, the rations described in Table 1. The weights of the rats and of the food consumed were recorded weekly.

The polished rice, red kidney beans, chickpeas, and soybeans were washed, cooked for one hour with sufficient water in an autoclave at 15 pounds pressure per square inch, dried in a current of air at 65° C, finely ground in a mill, and then analyzed for crude protein, fat, carbohydrate, ash and moisture, before being incorporated into the rations. These foodstuffs were cooked so as to simulate their preparation in the home for human consumption.

A vitamin mixture, which had the following composition, was incorporated into each kilo of the prepared rations before these were fed: thiamin chloride hydrochloride—2.0 mg., pyridoxine hydrochloride—2.0 mg., choline chloride—1.0 g., riboflavin—4 mg., niacin—2.5 mg., and calcium pantothenate—15 mg. One drop of a solution containing 0.5 g. of Haliver oil and 0.25 gr. of viosterol in 37.5 ml. of corn oil was fed biweekly to each rat. A salt mixture,[7] commercial cornstarch, and lard were used to adjust the mineral carbohydrate, and fat of the rations.

No attempt was made to equalize the percentage compositions of Rations 1, 2, and 3, except in the case of the fat content of Ration 1, which was made equal to that of Ration 3. In the preparation of these three rations, the polished rice was mixed with the red kidney beans, chickpeas, and soybeans in a ratio of two parts of polished

TABLE 1

Composition of Rations

Rations	Percentages of the Total Protein					Percentage Composition			
	Polished Rice	Red Kidney Beans	Chick-peas	Soy-beans	Casein	Protein	Fat	Carbo-hydrate	Mineral
1	39.0	61.0				12.3	9.7	76.5	1.5
2	43.1		56.9			11.6	7.1	79.6	1.7
3	29.5			70.5		17.9	9.7	70.3	2.1
4	31.9	68.1				13.2	6.9	75.2	4.7
5	31.9		68.1			13.2	6.9	75.4	4.5
6	31.9			68.1		13.2	6.9	75.2	4.7
7					100	18.0	5.0	72.0	5.0
8					100	13.2	5.0	76.8	5.0
9	31.9				68.1 Skim. Milk Supp.[a]	13.2	6.9	75.2	4.7
10	31.9	68.1				13.2	6.9	75.2	4.7
11	31.8	34.1	34.1			13.2	6.9	75.2	4.7
12	31.8	34.1		34.1		13.2	6.9	75.2	4.7

[a]Each rat received an average of 0.25 g. protein per day from the milk supplement.

7. P. H. Phillips and E. B. Hart, Effect of organic dietary constituents upon chronic fluorine toxicosis in the rat. J.Biol.Chem., **109**:657–663, 1935.

Average Gains, Food Intake, Protein Efficiency

Rations	No. of rats	Protein Percentages in Rations: Polished rice	Red kidney beans	Chickpeas	Soybeans	Casein	Total protein (percent)	5 Weeks: (1) Average gains (g.)	(2) Average food intake (g.)	(3) Protein Efficiency	8 Weeks: (1) Average gains (g.)	(2) Average food intake (g.)	(3) Protein Efficiency	10 Weeks: (1) Average gains (g.)	(2) Average food intake (g.)	(3) Protein Efficiency
1. 2 parts polished rice and 1 part red kidney beans	10	4.8	7.5				12.3	32.1	248.5	1.0	44.9	419.7	0.8			
2. 2 parts polished rice and 1 part chickpeas	10	5.0		6.6			11.6	44.5	282.5	1.4	65.5	470.9	1.2			
3. 2 parts polished rice and 1 part soybeans	10	5.2			12.7		17.9	47.6	249.4	1.0	63.4	423.7	0.8			
4. Polished rice and red kidney beans	20	4.2	9.0				13.2	51.3	254.4	1.5						
5. Polished rice and chickpeas	20	4.2		9.0			13.2	86.5	329.2	2.0				153.1	751.1	1.5
6. Polished rice and soybeans	20	4.2			9.0		13.2	86.9	336.2	2.0				147.3	752.9	1.5
7. Casein	10					18.0	18.0	107.6	350.1	1.7	154.2	661.5	1.3			
8. Casein	10					13.2	13.2	86.0	329.7	2.0	130.0	601.1	1.6			
9. Polished rice and casein	10	4.2				9.0	13.2	104.2	338.8	2.0	143.7	668.8	1.6			
10. Polished rice and red kidney beans (skim. milk powder supplement)	6	4.2	9.0				13.2	39.8	253.0	1.2				60.7	310.6	1.3[a]
11. Polished rice and red kidney beans and chickpeas	7	4.2	4.5	4.5			13.2	53.3	265.0	1.5				57.3	361.0	1.2
12. Polished rice and red kidney beans and soybeans	7	4.2	4.5		4.5		13.2	61.2	280.5	1.6				62.9	374.3	1.3

[a] An average of 0.25 g. of protein was supplied daily by the skimmed milk powder supplement during the last 5 weeks to this group of rats.

rice to one part of the legume. It is approximately in this proportion that the polished rice and red kidney beans are used in the Puerto Rican homes. Chickpeas are a traditional part of the diet of the Spaniard living in Puerto Rico, but soybeans are not used to any significant extent, although an effort has been made to encourage their consumption.

A summary of the data obtained, showing the average gains in weight, the average food consumed, and the protein efficiencies of the different rations, is given in Table 2.

DISCUSSION

Although no simple method exists for measuring the extent to which a protein meets all nutritional requirements, two different methods, in common use, give fair data for this determination, either with one protein or with mixtures. The method used in this study, the measurement of the growth promoting value of proteins, relates the growth of the experimental animal with the amount of protein consumed, this ratio being referred to as the protein efficiency.

The food consumption and average gain in weight of the rats fed on Ration 2 were better at the termination of the eight-week experimental period than for the animals that received Ration 3, even though the protein content of the latter ration was higher than that of the former; 6.6 percent of Ration 2 was protein derived from chickpeas and 12.7 percent of Ration 3 was protein from soybeans. The protein efficiency of Ration 2 was also greater at the end of the five- and eight-week experimental periods. These results indicate a superior supplementation of the polished rice proteins by the chickpea proteins. The average gain in weight and food consumption of the animals on the polished rice and red kidney beans ration, Ration 1, were less than in the case of Rations 2 and 3. The red kidney beans supplied 7.5 percent of the protein of Ration 1.

The group of rats placed on Ration 4 grew less and consumed less food than the rats receiving Rations 5 and 6. Protein efficiency for these three rations was 1.5, 2.0, and 2.0, respectively, over a five-week experimental period. The protein mixtures in these rations were derived from polished rice, 4.2 percent, and the legume that supplied 9.0 percent. The superiority of the chickpea and soybean proteins over the red kidney bean proteins is apparent.

The data obtained with the animals fed on Rations 5 and 6 show that, although practically the same amount of food was consumed

by both groups, the rats receiving Ration 5 gained more than those fed Ration 6. The protein efficiency was essentially the same for both rations. On the basis of these results, it seems justifiable to conclude that the chickpea proteins supplemented the rice proteins to the same extent as did the soybean proteins, when fed at the same level.

In view of the fact that the rats receiving Ration 4 consumed little of the food and showed a poor growth response, they were divided into three groups of six, seven, and seven rats each, and then placed on Rations 10, 11, and 12, respectively.

When skimmed milk powder to the extent of 0.5 g. daily during the first three weeks and 1.0 g. daily during the last two weeks of the five-week experimental period was fed as a supplement to the rats that were continued on Ration 4 (Ration 10), their average gain in weight increased from 39.8 g. in five weeks on Ration 4 to 60.7 g. in five weeks with the milk supplement. When 50 percent of the red kidney bean protein of Ration 4 was replaced by chickpea protein (Ration 11) and soybean protein (Ration 12), the average gain in weight of the animals for the following five-week period increased from 53.3 g. to 57.3 g. on Ration 11 and from 61.2 g. to 62.9 g. on Ration 12. Skimmed milk powder supplemented the rice proteins in a rice and red kidney bean mixture more efficiently than the chickpeas and soybeans proteins. The protein efficiency of these three rations was practically the same, although the rats receiving the skimmed milk supplement showed a greater average gain with less food consumption than the rats on the other two rations. All three groups of rats showed an improvement in their physical appearance when compared to their condition on Ration 4.

These results can be of practical value in improving the relatively poor mixture of polished rice and red kidney beans in common use in Puerto Rico. Skimmed milk could be utilized to replace part of the water necessary in the preparation of the mixture, and chickpeas or soybeans could be substituted for part of the red kidney beans. These changes would undoubtedly improve the protein quality of the diet.

Further evidence of the supplementary effect of milk proteins on polished rice proteins is demonstrated with the group of animals fed on Ration 9. This ration, consisting of 4.2 percent protein from polished rice and 9.0 percent protein from casein, promoted a greater average weight increase and food consumption than a ration containing 13.2 percent of casein as the sole source of protein.

The average weekly gain in weight of the animals, which received

Ration 7—the 18 percent casein ration—seems to be less than that which has been reported by other workers. This may have been due to the lack of some other vitamin or to the absence of liver in the ration.

SUMMARY

Growth experiments of comparable groups of rats fed on mixtures of polished rice, red kidney beans, chickpeas, and soybeans are described.

1. Rats, fed a polished rice and red kidney beans ration, showed a poorer growth response and consumed much less food than rats receiving a diet of polished rice and chickpeas, or a polished rice and soybeans ration.
2. The growth and food consumption of rats on the polished rice and chickpeas ration was comparable to that of the group of animals, fed on the polished rice and soybeans ration.
3. Skimmed milk powder supplemented the proteins of a polished rice and red kidney beans ration and promoted greater growth and better food consumption than that obtained without the milk.
4. Improved growth and food consumption resulted when either chickpeas or soybeans replaced part of the red kidney beans in a polished rice and red kidney beans ration.
5. Milk casein is an adequate supplement to polished rice proteins.

The application of these findings is discussed.

ACKNOWLEDGMENT

This opportunity is taken to thank Professor C. A. Elvehjem, Head of the Department of Biochemistry, College of Agriculture, University of Wisconsin, for his generosity in granting the author the facilities for doing this work.