

**THE COMPLEMENTATION EFFECTS ON DIETARY PROTEIN  
OF UNGERMINATED AND GERMINATED MUNG BEAN  
(*Phaseolus aureus*) WITH RICE<sup>1</sup>**

***Mohd Ismail Noor<sup>2</sup>, Roberto Gómez Brenes<sup>3</sup>, Ricardo Bressani<sup>4</sup>  
and Luiz G. Elías<sup>3</sup>***

**Institute of Nutrition of Central America and Panama (INCAP),  
Guatemala, C. A.**

**SUMMARY**

Biological evaluations using rats were carried out to determine the complementation effects on dietary protein of cooked mung bean/rice and cooked germinated mung bean/rice mixtures. On an isoproteic basis, mung bean protein was found to be of a lower quality than rice protein. Upon complementation with rice, however, the protein quality of the ungerminated and germinated mung bean/rice mixtures steadily increased when rice was incorporated to provide 25, 50 and 75% of the protein in the diet. A comparison study between germinated and ungerminated mung bean/rice mixtures indicated that the latter mixture was of a better protein quality. Nevertheless, replacement of 75% of the dietary protein of mung bean by rice showed no difference between the germinated and ungerminated mung bean.

**INTRODUCTION**

The complementary role of the proteins of food legumes and cereals has long been recognized. Food legumes, when combined with cereal foods, provide an almost ideal level of dietary proteins for humans and are therefore vitally important for the population of the less developed countries (1, 2). As is well known, the first limiting amino acids in legumes and cereals are methionine and lysine, respectively. Mixtures of legumes and cereals are better balanced in amino acid composition and biological value

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- 1 This work was carried out with the financial support of the United Nations University.
- 2 INCAP/UNU fellow, Food Science and Nutrition Unit, National University of Malaysia, Sangi, Malaysia.
- 3 Scientist, Division of Agriculture and Food Sciences of INCAP.
- 4 Head of the same Division.

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than either of the two components alone (1-3). Germinated mung bean has found its place in the day-to-day diet mainly consumed in the Orient, where it is served as a vegetable or mixed with cereals and cereal products. An earlier work on mung beans indicated that a significant decrease in protein quality does occur as a result of germination and cooking (4). Numerous investigators (1-3, 5, 6) have carried out studies on common bean/rice mixtures but as far as germinated bean/rice mixtures are concerned, studies are scarce. This study was performed to determine the optimum combination of the mixtures, in terms of protein quality, and to compare ungerminated and germinated mung bean/rice mixtures.

### MATERIALS AND METHODS

The mung bean (*Phaseolus aureus*) and polished rice used in this study were obtained from the local market. The mung bean was treated and germinated as described in our earlier investigations (4), with the exception that germinated mung bean was harvested at three days of germination, for purposes of the biological trials. The polished rice was cooked by the routine home-steaming process, ground, and the Kjeldahl N (7) was multiplied by 5.95.

The essential amino acid composition of germinated mung bean, at different days of germination, raw and cooked, and of cooked polished rice were determined in a Technicon TSM autoanalyzer, on 6 N HCl protein hydrolysates.

The study involved maintaining the protein content of the diet at 7.2% (Kjeldahl N (7) x 6.25) by mixing germinated and ungerminated mung bean with polished rice in proportionate amounts, in such a way that the nitrogen content of mung bean was progressively replaced by a compensating amount of polished rice nitrogen. These mixtures were then supplemented with calories, vitamins (8), and minerals (9) to make up the test diets as shown in Table 1.

The biological assays, net protein ratio (NPR) and true digestibility (TD) were carried out as described previously (4), with the following changes: NPU determinations were carried out at the end of the PER trial (28 days) while the TD was obtained in the last week of the PER studies.

### RESULTS AND DISCUSSION

The essential amino acid composition of raw and cooked germinated mung bean, at different germination times, and also the pattern of cooked rice, are shown in Table 2.

There is no clear trend as to the levels of amino acids with germination time, although the tendency is for slightly lower values at four days of germination from the initial value, with the exception of aspartic acid. In general, the same seems to be true for the germinated cooked samples. The effects of hydrolysis of the samples for amino acid analysis probably play a more important role than germination in the values found, more evident in the case of methionine content, which is very low, as compared to other amino acids.

TABLE 1  
COMPOSITION OF EXPERIMENTAL DIETS (g/kg/diet)

Bean*	Rice	Bean*	Rice	Other ingredients**	Corn-starch	Casein
Ratio		g	g	g	g	
100	0	230	—	100	670	—
75	25	170	220	100	510	—
50	50	114	444	100	342	—
25	75	57	666	100	177	—
0	100	—	900	100	—	—
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Casein control (7.1%o prot.)		—	—	100	821	79
Casein control (10.0%o prot.)		—	—	100	789	111

\* Ungerminated and germinated cooked mung beans.

\*\* 5%o cottonseed oil, 4%o mineral mixture (9), 1%o cod liver oil and 50 ml of vitamin mixture/kg diet (8).

TABLE 2  
AMINO ACID CONTENT OF GERMINATED MUNG BEAN, RAW AND COOKED,  
AND OF COOKED RICE (mg/16 g N)

	0 days		2 days		3 days	4 days		Rice cooked
	R	C	R	C	C	R	C	
Lysine	359	400	387	311	372	328	349	222
Histidine	183	142	178	165	—	139	154	141
Arginine	—	303	390	295	—	285	335	477
Asp. acid	834	757	965	—	920	922	897	548
Threonine	152	148	147	116	118	145	140	167
Serine	133	128	122	72	95	119	122	187
Glut. acid	1,008	940	687	467	591	819	798	913
Proline	272	245	269	200	184	219	218	313
Glycine	340	295	234	236	210	267	269	139
Alanine	231	215	213	200	181	224	227	319
Valine	394	366	379	410	351	385	383	184
Methionine	20	52	32	33	38	57	63	88
Isoleucine	435	420	398	421	402	436	434	465
Leucine	430	419	379	332	381	413	404	555
Tyrosine	—	114	125	114	125	137	124	177
Phenylalanine	349	310	312	290	362	344	316	332

Table 3 summarizes the lysine, methionine and threonine content of raw and cooked ungerminated and germinated samples. These three amino acids will determine the protein quality of blends between the two foods. As the data show, mung bean contains higher levels of lysine than rice; however, the levels are not as high as those found in other food legumes, and they are just slightly higher than those of the FAO pattern. On the other hand, as already established (10,11), rice is deficient in its content. Because of partial destruction of methionine during acid hydrolysis, and because of the fact that cystine content is not shown, not much can be said about total sulfur amino acid values. Nevertheless, it is well established that food legumes are deficient in sulfur amino acids (2). On the other hand, rice protein contains around 190 mg sulfur amino acids per gram of nitrogen, a value which is lower than that of the FAO pattern. Finally, threonine values are low in both mung bean and rice protein. It has been demonstrated that threonine supplementation of rice in the presence of lysine improves its protein quality.

The biological evaluation of ungerminated mung bean/rice mixtures, using rats, is presented in Table 4. In this case, significant differences were observed in the values of NPR (3.71 – 3.99), PER (1.65 – 1.92), NPU (43.0 – 46.0 and TD (82 – 83.0) of the mixtures when rice was added to provide 25, 50 and 75% of the protein in the diet, respectively. Values obtained for mung bean revealed that the protein was of a poorer quality, while rice protein was superior when compared with the other treatments.

The biological evaluation of germinated mung bean/rice mixtures using rats is detailed in Table 5. Findings showed the same tendency, higher value in rice, and an expected low value from germinated mung bean. In the mixtures, with the exception of TD (79.0 – 80.0), however, a significant increase in protein quality was observed in NPR (2.58 – 3.81), PER (1.07 – 2.05) and NPU (32.0 – 44.0) when rice was added to provide 25, 50 and 75% of the dietary protein of the test diets.

Results of NPR and PER studies are illustrated in Figure 1. The poor amino acid pattern in the mung bean protein (Table 3) was reflected in the low NPR and PER values as compared to rice protein. When measured

TABLE 3

LYSINE, METHIONINE AND THREONINE CONTENT IN GERMINATED MUNG BEANS AND RICE (g/16 g N)

Germination days	Lysine		Methionine		Threonine	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
0	0.359	0.400	0.020	0.052	0.152	0.148
2	0.387	0.311	0.032	0.033	0.147	0.116
3	—	0.372	—	0.038	—	0.118
4	0.328	0.349	0.057	0.063	0.145	0.140
Rice	—	0.222	—	0.088	—	0.167
FAO/OMS	0.340		0.220		0.250	

TABLE 4

**BIOLOGICAL EVALUATION OF GERMINATED MUNG BEAN\*:  
RICE MIXTURES IN RATS\*\***

Diet	Treatment bean:rice	Net protein ratio	Protein efficiency ratio	Net protein utilization***	True digestibility
1	100: 0	1.72 <sup>e</sup>	0.61 <sup>e</sup>	26.0 <sup>d</sup>	85.0 <sup>b</sup>
2	75: 25	2.58	1.07 <sup>d</sup>	32.0 <sup>d</sup>	79.0 <sup>c</sup>
3	50: 50	3.20 <sup>c</sup>	1.58 <sup>c</sup>	38.0 <sup>cd</sup>	79.0 <sup>c</sup>
4	25: 75	3.81 <sup>b</sup>	2.05 <sup>b</sup>	44.0 <sup>bc</sup>	80.0 <sup>c</sup>
5	0:100	4.02 <sup>b</sup>	2.20 <sup>b</sup>	45.0 <sup>bc</sup>	80.0 <sup>c</sup>
6	Casein control	4.82 <sup>a</sup>	2.75 <sup>a</sup>	56.0 <sup>a</sup>	89.0 <sup>a</sup>

\* Cooked germinated mung bean (3 days).

\*\* Mean values for 8 rats (4 ♂ + 4 ♀) per diet.

All means without a common superscript differ significantly ( $P < 0.05$ ).

\*\*\* NPU — 28 days duration.

TABLE 5

**BIOLOGICAL EVALUATION OF UNGERMINATED MUNG BEAN\*:  
RICE MIXTURES IN RATS\*\***

Diet	Treatment bean:rice	Net protein ratio	Protein efficiency ratio	Net protein utilization***	True digestibility
1	100: 0	3.06 <sup>c</sup>	0.71 <sup>d</sup>	28.0 <sup>c</sup>	83.0 <sup>b</sup>
2	75: 25	3.71 <sup>bc</sup>	1.65 <sup>c</sup>	43.0 <sup>b</sup>	82.0 <sup>b</sup>
3	50: 50	3.69 <sup>bc</sup>	1.85 <sup>bc</sup>	45.0 <sup>b</sup>	82.0 <sup>b</sup>
4	25: 75	3.99 <sup>b</sup>	1.92 <sup>bc</sup>	46.0 <sup>b</sup>	83.0 <sup>b</sup>
5	0:100	4.02 <sup>b</sup>	2.20 <sup>b</sup>	45.0 <sup>b</sup>	80.0 <sup>b</sup>
6	Casein control	4.82 <sup>a</sup>	2.75 <sup>a</sup>	56.0 <sup>a</sup>	89.0 <sup>a</sup>

\* Cooked ungerminated mung bean.

\*\* Mean values for 8 rats (4 ♂ + 4 ♀) per diet.

All means without a common superscript differ significantly ( $P < 0.05$ ).

\*\*\* NPU — 28 days duration.

on an isoproteic basis, the protein of rice was superior to that of bean protein. Similar findings were reported by Bressani (1) and by Bressani, Elías and Gómez Brenes (3). In both studies, the maximum combination achieved, in terms of protein quality, occurred when rice provided 75% of the protein, and bean 25%. However, a significant increase in protein quality was observed in favor of the ungerminated mung bean/rice mixture when rice replaced 25% of the bean protein.

Figure 2 presents the results of the NPU and TD studies. In the case of NPU, the maximum combination was observed at a similar protein re-

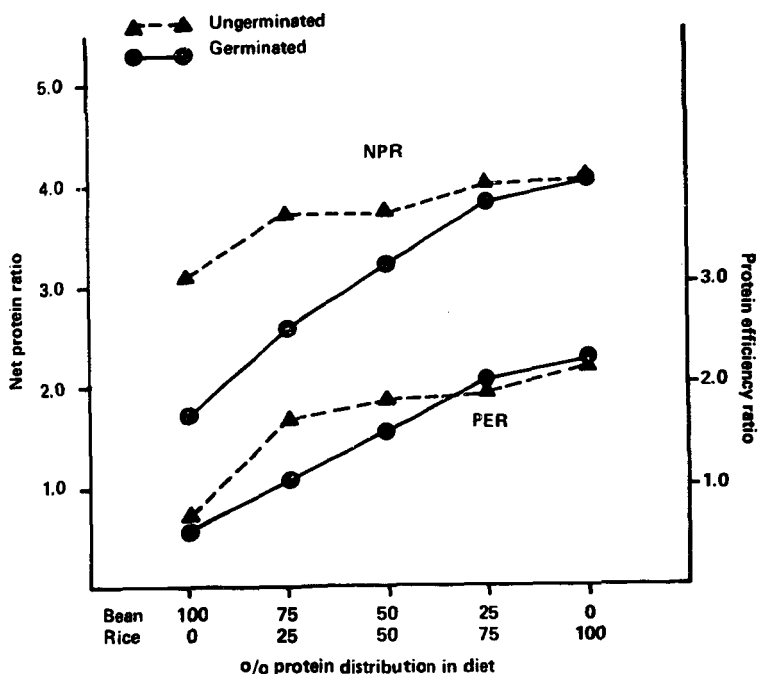


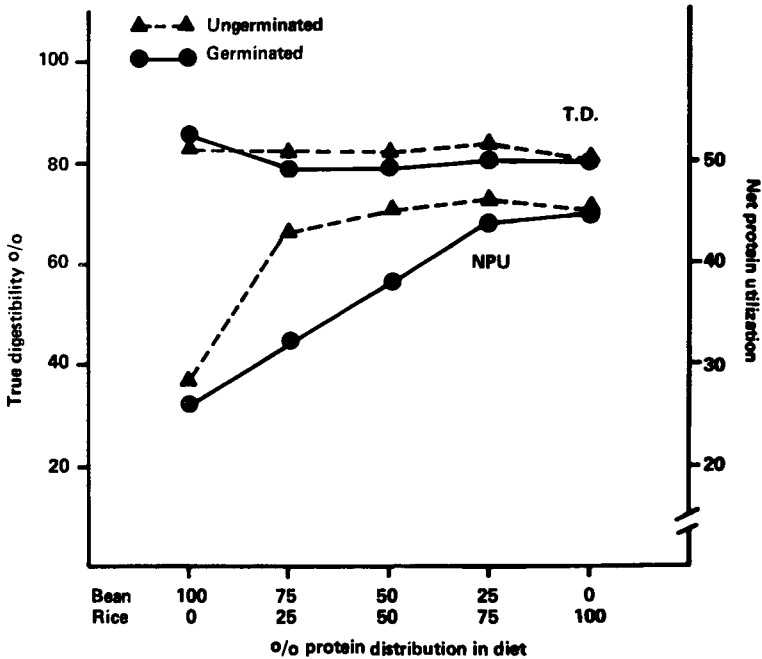
FIGURE 1

Incap 84-2

Net protein ratio and protein efficiency ratio of mung bean  
(*Phaseolus aureus*):rice mixtures

placement level by rice (75%) as found in the NPR and PER studies. A significant increase in NPU value, from 28.0 to 43.0 also occurred when rice replaced 25% of the bean protein. These results, however, may differ from similar studies, since the NPU was calculated over a period of 28 days. The TD studies indicated a very small difference in values in both of the mixtures. Nevertheless, the effect of sprouting, coupled with heat treatment, may influence the higher value recorded in the cooked germinated bean diet (4, 12, 13); this result was in agreement with the findings of Venkataraman, Jaya and Krishnamurthy (14). Bressani (15) found that the true protein digestibility tends to increase with a decrease in protein intake, especially with proteins of vegetable origin. Bressani and Elfas (2, 16) further suggested that an additional increase in protein digestibility probably results from the destruction of the tertiary structure of certain proteins which offer resistance to enzymatic hydrolysis.

The necessity of a heat treatment of legume seeds and their products in order to destroy toxic and antigrwth factors, has been stressed by Liener (17). Our earlier work (4) indicated that mung bean has a low inhibitor activity, and no mortality was recorded in rats fed on a raw mung bean diet. Evans and Bauer (18) reported that growing rats fed on raw autoclaved bean did not absorb 50% of the methionine and 41% of the bean cystine. This may suggest that such effect may be more severe in



Incap 84-1

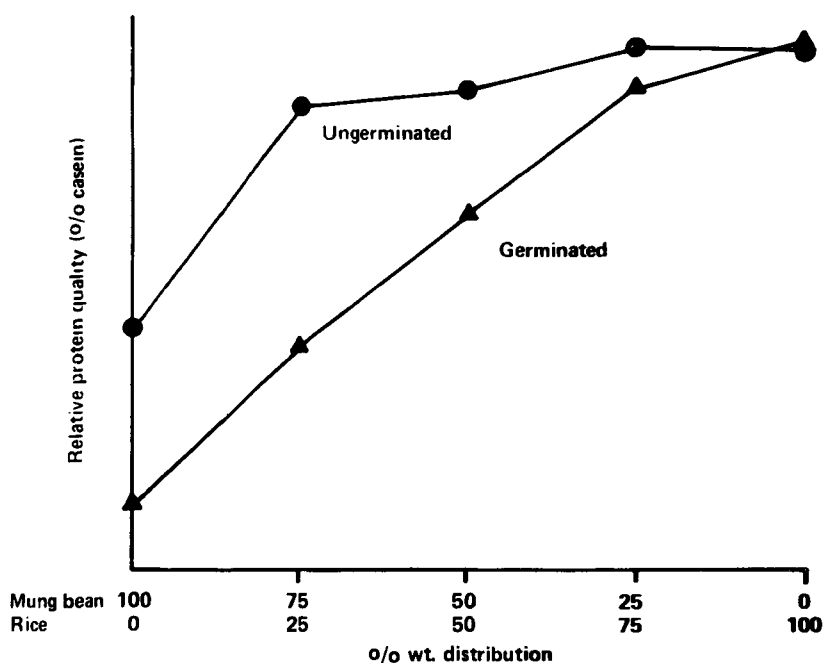
FIGURE 2

Net protein utilization and true digestibility of mung bean:rice mixtures

the case of germinated mung bean (4) as found in both our studies.

This study may be considered partially complementary in nature. Bean protein is a rich source of lysine, while its methionine content is highly deficient. On the other hand, rice protein has lower concentrations of lysine but is adequate in its sulfur amino acids content (1, 3, 10). Once the best combination is reached, the protein value of the mixture remains relatively constant when compared with rice. Although protein complementation increases the efficiency of utilization by improving the overall amino acid composition, in some cases it is still far from being ideal in meeting the amino acid requirement of the rats.

The average protein quality values relative to casein of all the assay results have been plotted in Figure 3; this figure shows that the protein quality lines responding to the different combination of mung beans and rice, are not alike between mixtures using ungerminated and germinated mung beans. The difference is more obvious in the area of 100 to 50% distribution of mung beans and 0 to 50% rice. For ungerminated mung beans, a plateau value is reached with a mixture 75/25 bean/rice, while there is a continuous increase for the germinated bean/rice mixtures. Obviously, the difference is due to the different amino acid content of ungerminated and germinated beans, in particular, lysine, sulfur amino acids,



Incap 84-3

FIGURE 3

Relative protein quality to casein of mixtures of germinated and ungerminated mung beans and of rice

and threonine. As indicated previously (4), germination reduces the values of these and other essential amino acids as well. This aspect is evident when observing the protein quality at 100% mung beans, which is lower in germinated as compared to ungerminated beans. The effects of processing should not be ignored, since it has been proved that it reduces protein quality when not well controlled (12, 14).

Since the dietary protein of rice was superior at the levels provided, as found in both studies, the results obtained indicated that the mixture of ungerminated mung bean/rice was superior to that of germinated mung bean/rice. Perhaps the most significant aspect of this work was the ability of mung bean to complement rice adequately at a relatively low intake of 5.7% bean to 66.6 g rice, an approximate ratio of 1:12 by weight. Therefore, these findings may serve as a useful indicator in areas where mung bean sprouts and rice are widely consumed.

## RESUMEN

**EFFECTOS DE LA COMPLEMENTACION ENTRE LA PROTEINA  
DEL FRIJOL MUNGO (*Phaseolus aureus*) GERMINADO  
Y NO GERMINADO Y LA DE ARROZ**

Se realizaron estudios de evaluación biológica en ratas para determinar el efecto complementario de la proteína del frijol mungo cocido y arroz, y del frijol mungo germinado y cocido con arroz. En bases isoproteínicas, se encontró que la proteína del frijol mungo es de calidad inferior a la de la proteína del arroz. Sin embargo, en la complementación con arroz, la calidad proteínica de frijol mungo no germinado o germinado en mezclas con arroz, aumentó continuamente cuando el arroz se incorporó en las proporciones de 25, 50 y 75% de la proteína de la dieta. Un estudio comparativo entre mezclas de frijol mungo y arroz, con el frijol mungo no germinado o germinado, reveló que las mezclas con frijol mungo no germinado eran de calidad proteínica superior. No obstante, la sustitución del 75% de la proteína dietética del frijol mungo por proteína de arroz demostró no ser diferente entre el frijol mungo no germinado y el germinado.

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