PROTEIN QUALITY OF FOODS. II.
Application of Acceptable Parameters to Assess and Improve Diets

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ABSTRACT

Poor quality of protein in copra meal diet was attributed more to poor digestibility than to poor nitrogen retention; in mungbean diet, it was due more to poor nitrogen retention than to poor digestibility. Nitrogen utilization of both diets decreased when protein levels were increased. The copra meal-fish meal mixture greatly increased its nitrogen utilization when diluted with protein, but further improvement was observed when 0.07% methionine was added to the mixture. In mungbean diet, supplementation with methionine greatly improved its nitrogen retention. The deleterious effect caused by feeding high level of copra meal may be attributed to high excretion of urea.

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KEY WORDS: Protein quality. Copra meal. Mungbean. Diets. Supplementation. Biological parameter. Biochemical parameter. Nitrogen retention. Digestibility.

INTRODUCTION

After evaluating the biological and biochemical parameters for determining protein quality, the next step is to apply these parameters to products that are cheap sources of protein for animals (i.e., copra meal) and for man (i.e., mungbean).

Copra meal is a coconut by-product derived after extracting oil from coconut. Because of its abundant supply, it is utilized as animal feed. However, it has low feed efficiency and is considered toxic when incorporated at high levels in the animal ration. Meanwhile, mungbean is a legume food nutritionists consider as a possible meat substitute. However, as to how effective it is as a replacer or how it can be improved to approximate the standard of the replaced protein has not been well-studied.

Protein quality is dependent on its amino acid content. The absence of limiting amino acid would make the protein almost useless. This deficiency could be corrected through amino acid supplementation or mixing with other proteins

MATERIALS AND METHODS

Experimental details have been described in the preceding article. Controlled feeding of 9 g per day and balance periods of 6 days were used in this study. The amount of amino acid added to the diet was determined by comparing the amino acid content of the protein source with that of the amino acid content of egg albumin (standard). The most deficient amino acid was increased by supplementation.

The formulation of the diets along with their dry matter and protein contents are shown in Tables 1 and 2.

RESULTS AND DISCUSSION

Protein Quality of Copra Meal and Mungbean Diets.

Results showed that poor quality of protein in the copra meal diet was due more to poor digestibility than to poor nitrogen retention while the reverse was true in the mungbean diet (T3-4). The true digestibility (TD) value obtained from the copra meal diet was about 60%, which is close to the TD of 67.2% given by Krishnamurthy *et al.* (1958) but 21% lower than the value given by the Food and Agriculture Organization

Table 1. Detailed formulation (g/kg, air dry basis) and dry matter and protein composition of the copra meal and mungbean diets fed to rats.

Constituents	Albumin (%)		Copra Meal (%)			Cooked Mungbean (%)			Raw Mungbean (%)
	1	8	4	6	8	4	6	8	
Maize starch	610	540	337	195.5	53.9	396.2	264.3	172.4	160.2
Cellulose	80	80	58	47	36	42.9	24.4	5.8	5.8
Glucose	160	160	160	160	160	160	160	160	160
Maize oil	100	100	74.3	61.5	48.7	97.9	96.9	95.8	95.8
Vit-Mix	20	20	20	20	20	20	20	20	20
Min-Mix	20	20	20	20	20	20	20	20	20
Albumin	10	80	—	—					
Albumin	10	80	—	—	—	—	—	—	—
Copra meal	—	—	195.5	293.2	391	—	—	—	—
Cooked mungbean	—	—	—	—	—	163.8	245.7	327.6	—
Raw mungbean	—	—	—	—	—	—	—	—	339.8
Dry matter, %	91.33	91.93	91.04	92.72	92.13	92.16	92.25	92.86	92.83
Crude Protein, % (as fed)	1.42	5.64	4.38	7.31	10.9	4.56	6.63	9.74	10.97

Table 2. Detailed formulation (g/kg, air dry basis) and dry matter and protein composition of the copra meal and supplement copra meal diets, and the mungbean and amino acid supplemented mungbean diets fed to rats.

Constituents	Albumin (%) 1	Albumin (%) 8	CM	Copra Meal (8% Protein) CM-FM	CM-FM M	CM-FM M I	Mung	Raw Mungbean (8% Protein) Mung M	Mung MT
Maize starch	610	540	318	410	410	410	353	353	353
Cellulose	80	80	35	57	57	57	3	3	3
Glucose	160	160	160	160	160	160	160	160	160
Maize oil	100	100	47	68	68	68	96	96	96
Vit-Mix	20	20	20	20	20	20	20	20	20
Min-Mix	20	20	20	20	20	20	20	20	20
Egg albumin	10	80	—	—	—	—	—	—	—
Copra meal	—	—	400	200	200	200	—	—	—
Raw mungbean	—	—	—	—	—	—	348	348	348
Fish-meal	—	—	—	65	65	65	—	—	—
L-Methionine	—	—	—	—	.7	.7	—	1.8	1.8
L-Isoleucine	—	—	—	—	—	1.2	—	—	—
L-Tryptophan	—	—	—	—	—	—	—	—	0.7
Dry matter, %	90.57	91.39	91.11	91.16	91.39	91.54	90.29	90.54	90.38
Crude Protein, % (as fed)	1.01	6.54	7.78	7.99	7.93	7.93	7.63	7.77	7.60

Legend:
CM - Copra meal FM - Fish meal M - Methionine I - Isoleucine T - Tryptophan

(1970). In mungbean, the actual TD and biological value (BV) of about 85% and 55, respectively, are close to the findings of Pant and Kapur (1963) which were 83.21% for TD and 51.57; FAO gave a BV of 70 for mungbean.

As in the previous experiments, protein level affected the efficiency of nitrogen retention. The BV decreased with an increase in the protein level of the diet, while nitrogen excretion increased with an increase in the protein level.

The low nitrogen retention of poor protein diets could be attributed to many factors most outstanding of which may be the non-utilization of the available amino acids due to the poor amino acid profile which in turn could not support protein synthesis. Another reason may be the poor appetite of the animals fed the diets with poor protein quality. The low nitrogen retention of poor protein diets are well-studied. Harper (1964) listed the possible causes of depressed food intake and growth which are usually observed after feeding with diets containing poor quality proteins. These are (1) delayed stomach emptying, (2) depressed rate of protein digestion, (3) delayed amino acid absorption and transport, (4) increased amino acid excretion and catabolism, (5) depressed rate of protein synthesis, and (6) altered plasma amino acid pattern. The altered amino acid pattern of the plasma might have induced a feeling of satiety. Harper (1964) thought

Table 3. True digestibility (TD), biological value (BV), net protein utilization (NPU), liveweight gain (LWG) and urine and serum nitrogen data in rats receiving copra meal and mungbean diets at increasing levels of protein.

Diet	Dietary Level %	TD %	BV	NPU	Urine Nu mgN/9 days	Urine Nt mgN/9 days	Nu/Nt	Nu/Na	Serum Total Protein g/100cm³
Albumin	7	98.61a	94.34a	91.20a	109.0d	216.0e	49.23e	16.52e	5.85a
Copra meal	4	64.99c	75.21b	49.23bc	151.5d	252.0e	60.72d	50.16cd	5.77a
	7	57.65d	66.07c	38.03de	220.2c	328.4d	67.74c	46.76d	5.20b
	10	59.44d	54.81de	32.58e	406.8b	535.6b	75.58b	54.21c	4.83b
Mungbean	4	86.60b	59.71d	51.78b	253.4c	334.4d	75.70b	65.44ab	3.91cd
Cooked	7	83.00b	52.53e	43:72cd	413.6b	478.8c	86.85a	67.32a	4.26c
	10	83.21b	51:57e	42.90d	556.4a	638.8a	87.02a	60.43b	4.11c
Uncooked	10	86.61b	57.37d	49.73bc	530.2a	622.6a	85.20a	51.71cd	3.72d
F-Value		327.47	11.18	21.38	31.32	23.92	18.34	14.22	3.42
SE		2.29	2.56	2.99	27.37	27.14	2.27	2.77	.19
LSD		4.62	5.23	6.03	55.30	54.30	4.59	5.59	.38

Means followed by a common letter are not significantly different at 5% level using DMRT.

that appetite depression was possibly a homeostatic response which prevented an undue change in the internal environment.

Close correlation was found between BV and the other parameters. Correlation coefficient of -0.90 was found between BV and Nu/Na; -0.95 between BV and Nu/nt; -0.83 between BV and Nu; -0.81 between BV and Nt; and, 0.81 between BV and serum total protein.

Diet Supplementation.

Addition of fish meal improved the nitrogen retention for copra meal while addition of supplementary methionine significantly ($P>0.05$) improved BV. This shows the extremely low level of methionine found in copra meal-fish meal.

The improved nutrition value of mixed proteins was attributed by Woodham (1978) to the provision of better amino acid balance and the overcoming of amino acid excesses which may prove to be deleterious. Ostrouski (1978), on the other hand, suggested that a protein which has a surplus of one indispensable amino acid can be diluted with another protein which is limited in that amino acid. This was found true in this study where the high lysine of fish meal might have compensated for the low lysine of copra meal.

In mungbean diet which was deficient in nitrogen retention, it was calculated that supplementation of 0.8% level of methionine, the first limiting amino acid, greatly improved the feeding value of the diet. On the other hand, supplementation with tryptophan, the second limiting amino acid, did not significantly improve the results. This confirms the finding of Bunce *et al.* (1971) that addition of tryptophan and isoleucine to a methionine-supplemented diet did not further improve the diet.

An increase in nitrogen retention by supplementing copra meal-fish meal diet and mungbean diet with methionine was shown with a concomitant decrease in Nu, Nt, Nu/Nt and serum urea. The same phenomenon was also observed by Kiriyama (1970). One can deduce that methionine, the limiting amino acid in the diet, improved the absorbed amino acid profile when it was supplemented thus resulting in a decrease in amino acid catabolism and urea excretion in one hand and the synthesis of protein in the other, as shown by the significant increases in liveweight gains.

Harper (1964) reported that omitting only one of the indispensable amino acids from the diet resulted in failure of the body to use the others, except as source of energy.

There was a high correlation between BV and the other parameters except in the case of serum total protein. This phenomenon could not be explained here. The correlation coefficients were -0.98 between BV and Nu/Na; -0.96 between BV and Nu/Nt; -0.94 between BV and Nu; -0.93 between BV and Nt; 0.91 between BV and LWG; and, -0.78 between BV and serum urea.

The reason why the feeding value of the copra meal decreased with increasing level of the meal in the diet has never been explained, except to say that copra meal is toxic at high levels. This was due to some ill effects upon the animal, such as loss of weight and appetite, weakness and poor appearance. Based on the results of this study, one may attempt to explain this effect. As the level of the copra

Table 4. True digestibility (TD), biological value (BV), net protein utilization (NPU), liveweight gain (LWG) and urine and serum nitrogen data in rats receiving copra meal and copra meal supplemented diets and mungbean supplemented diets at 8% protein level.

Diet	TD	BV	NPU	Urine		Nu/Nt	Nu/Na	Serum		LWG
	%	mgN/6	mg/100	Nu mg/N/9 days	Nt mg N/9 days			Urea mg/100 cm³	Total Protein mg/100cm³	g/6 days days
Albumin	99.56a	95.82a	95.41a	77.99a	130.22e	60.04f	15.03d	13.38e	5.21c	10.2a
CM	55.60e	64.90d	36.14e	178.95b	226.51b	79.03b	54.23a	22.21c	4.32f	1.0e
CM-FM	75.03d	78.89c	59.29c	158.04c	209.16c	75.02c	33.45b	22.10c	4.39e	4.6d
CM-FM M	71.74d	84.63b	60.73c	116.47d	175.98d	66.18e	25.99c	16.70d	4.88d	6.8c
CM-FM MI	72.47d	81.27bc	58.89c	134.21d	194.28c	68.86e	29.62cb	18.21d	4.94d	5.2d
Mungbean	84.11c	59.65e	50.25d	275.16a	305.63a	90.33a	57.44a	46.22a	4.66d	0.0f
Mung M	88.09b	80.96bc	71.37b	151.59c	208.58c	72.77cd	27.67c	28.16b	5.88b	8.6b
Mung M T	88.07b	78.90c	69.46b	156.63c	225.36b	69.56d	29.23cb	18.78d	5.81a	8.6b
F-Value	121.21	636.47	68.00	29.16	15.42	23.53	36.52	29.10	8.18	23.50
SE	2.05	1.84	2.67	9.18	8.43	1.52	2.28	1.58	.10	.60
LSD	4.14	3.71	5.39		17.03	3.08	4.62	3.15	.20	1.21

Means followed by a common letter are not signifi[illegible]erent at 5% level using DMRT.

CM - Copra Meal FM - Fish meal M - Methionine
I - Isoleucine T - Tryptophan

meal in the diet increased, the level of urine Nu and Nt also increased, from 151.0 mg and 252:0 mg at 20% copra meal (4% protein) to 406.8 mg and 535.5 mg at 42% copra meal (10% protein). This means that the animal's renal system has to do considerable work to eliminate the unutilized nitrogen, mainly in the form of urea. Added to this is the presence of high urea in the blood which may prove to be toxic and the extra work exerted on an already protein-deficient animal may put a heavy stress on the animal. This was also observed on the zein diet and, to a lesser extent, on the mungbean diet.

The low nitrogen retention for mungbean diets calls for the need to supplement mungbean with nitrogen sources. This could be done either by mixing mungbean with other protein sources or by supplementing with amino acid. Otherwise, meeting the protein need from mungbean alone would mean high excretion of nitrogen, resulting not only to waste but to undesirable physiological effect.

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