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STUDIES ON A PROCESSED PROTEIN FOOD BASED ON A BLEND OF GROUNDNUT FLOUR AND FULL-FAT SOYA FLOUR FORTIFIED WITH ESSENTIAL AMINO ACIDS, VITAMINS & MINERALS

VI. THE EFFECT OF A SUPPLEMENTARY PROTEIN FOOD ON THE DIGESTIBILITY COEFFICIENT, BIOLOGICAL VALUE AND NET PROTEIN UTILISATION OF POOR RICE DIET IN UNDERNOURISHED CHILDREN

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In previous papers of this series[1,2] it has been reported that supplementation of the diet of undernourished school children (girls aged 9-10 years) daily with 40g of protein food based on a 1 : 1 blend of groundnut flour and full-fat soya flour fortified with l-lysine, dl-methionine and adequate amounts of calcium salts and vitamins A and D, thiamine and riboflavin brought about a significant improvement in their growth as well as an increase in their retention of N, Ca and P. The present paper describes the results of studies on the digestibility coefficient and biological value of the protein and net protein utilization of rice and rice-protein food diets given to children.

Experimental

Materials: The composition of the protein food based on a 1 : 1 blend of groundnut flour and full-fat soya flour fortified with l-lysine, dl-methionine, calcium salts and vitamins A and D, thiamine and riboflavin and of the diets consumed by the children were the same as those given in an earlier paper.[1] The contents of essential amino acids in the mixed proteins of the diets consumed by the children, determined by the method of Krishnamurthy *et al*[3]., are given in Table I, as compared with FAO reference protein pattern[4] and Ideal reference protein pattern.[5]

Table I. *Essential amino acid content of the mixed proteins of the different diets*

Amino acid (g/16g N)	Rice diet	Rice diet + protein food	FAO reference protein pattern	Ideal reference protein pattern
Arginine	5.30	6.82	—	6.6
Histidine	2.00	2.21	—	2.4
Lysine	4.47[2]	5.51	4.2	7.5
Tryptophan	1.03	1.12[1,2]	1.4	1.6
Phenylalanine	5.32	5.31	2.8	5.8
Methionine	1.67	2.26	2.2	2.8
Cystine	1.45	1.55	—	2.0
Total S-amino acids	3.12[1]	3.81	4.2	4.8
Threonine	3.52	3.67	2.8	5.0
Leucine	7.31	7.23	4.8	10.0
Isoleucine	4.76	4.84	4.2	6.6
Valine	5.51	5.39	4.2	7.0
Protein Score (1)	74	80	100	—
,, (2)	56	70	—	100

[1] Limiting amino acids when compared to FAO reference pattern.
[2] Limiting amino acids when compared to Ideal reference Pattern.

Metabolic study: The details of the metabolic study have been described by Parthasarathy *et al*.[2] The subjects were eight pairs of girls aged 9-10 years belonging to low-income groups of the population and receiving the control boarding home diet or the same supplemented with the protein food. The experimental procedure followed for feeding, collection and analysis of the diet, urine and faeces have already

been described.[2] At the end of 5½ months feeding period, the subjects were fed on a low-protein diet (Table II) for a period of 10 days for the determination of the endogenous urinary and faecal N. The first 5 days were treated as a preliminary period to allow the subjects to get accustomed to the diet. Urine and faeces were collected during the last five days for the determination of endogenous urinary and faecal nitrogen. The low-protein diet consisted of savoury and sweet preparations made from vermicelli obtained from cooked maize starch and tapioca flour (washed with alkali to remove traces of protein), sago pudding, lemon juice and vegetable soup. The digestibility coefficient and biological value of the proteins of the diets were calculated according to Tasker *et al.*[6] and Joseph *et al.*[7] The net protein utilisation (operative) [NPU (op)], net dietary protein value (ND-pv) and net dietary protein calories % (ND-p Cals %) were calculated according to Platt *et al.*[8]

Table II. *Mean daily intake (g) of food stuffs by the children on a low-protein diet*[1]

Maize Starch	120.0
Tapioca flour (washed with dilute alkali)	... 55.0
Sago	... 30.0
Cane sugar	... 50.0
Groundnut oil	... 50.0
Vitaminised sugar[2]	... 5.0
Common salt, refined	... 12.0
Salt mixture[3]	... 5.0
Onion	... 20.0
Tamarind Pulp	... 6.0
Condiments (garlic, coriander seeds, mustard, red chillies, turmeric)	... 10.0
Pumpkin	... 10.0
Brinjal (*Solanum melongena*)	... 10.0
Lemon juice	... 60 ml

[1] Nitrogen content of the diet, 0.15% ; calorie value, 1520 K Cal.

[2] Provided the daily requirements of the vitamins recommended by the (U.S.A.) National Research Council Food and Nutrition Board (1958).

[3] Osborne and Mendel salt mixture.

Results

The results of measurement of endogenous urinary and faecal N excretion are given in Table III and of the digestibility coefficient, biological value and net protein utilisation of the protein in Tables IV-VI. The net available protein from the different diets is given in Table VII.

Table III. *Heights and weights of the children and daily urinary and faecal excretion of nitrogen by the children on the low protein-diet.*

Girl No.	Height (cm)	Weight (kg)	Nitrogen excretion		
			Urinary (g)	Faecal (g)	Total (g)
Control (rice-diet) group					
1.	132	25.9	1.58	0.91	2.49
2.	129	22.7	1.52	0.84	2.36
3.	122	23.1	1.50	0.80	2.30
4.	122	21.3	1.50	0.74	2.24
5.	121	19.1	1.14	0.56	1.70
6.	118	18.3	1.15	0.61	1.76
7.	122	21.5	1.20	0.65	1.85
8.	111	17.7	1.12	0.47	1.59
Mean value with its standard error (7df)			1.34 ±0.07	0.70 ±0.05	2.04 ±0.12
Experimental (rice diet + protein food) group					
9.	130	23.2	1.51	0.90	2.41
10.	127	22.9	1.49	0.82	2.31
11.	126	22.9	1.46	0.82	2.28
12.	121	21.4	1.48	0.79	2.27
13.	120	20.9	1.21	0.68	1.89
14.	118	18.7	1.15	0.56	1.71
15.	122	21.1	1.40	0.79	2.19
16.	109	17.0	1.16	0.56	1.72
Mean value with its standard error (7df)			1.36 ±0.06	0.74 ±0.04	2.10 ±0.10

Protein scores (Table I) : The protein scores of the mixed proteins of the diets containing the supplements of the protein food (80) calculated by the method of FAO[4] was higher than that (74) of the control rice diet. A similar trend of results was observed when the protein scores of diets were the calculated according to the Ideal reference protein pattern of Swaminathan.[5] The protein scores of the diets calculated according to ideal reference protein pattern for the rice diet and rice protein food diet were 56 and 70 respectively.

Endogenous urinary and faecal nitrogen (Table III) : The mean daily urinary and faecal excretions of nitrogen for children on the low-protein diet were 1.34 – 1.36g and 0.70 – 0.74g respectively.

Digestibility coefficient and biological value of the proteins (Table IV) : The mean true digestibility coefficient of the mixed proteins of the rice-protein food diet (91.8) was significantly higher than that (85.5) of the proteins of the rice diet. The biological value of the proteins of the rice diet (65.1), however, was significantly higher than that (55.6) of the proteins of rice-protein food diet. This may be due to the fact that the level of protein in the rice-protein food diet (15.32%) is higher than that (10.52%) in rice diet.

NPU (op) and ND-p cals% (Table V) : The NPU(op) value of the rice-diet (55.8) was higher than that (51.0) for the rice-protein food diet. The ND-p Cals% (7.61) and the net available protein per kg body weight (1.39g) on the rice protein food diet were, however, significantly higher than those (5.87 and 1.04g respectively) for the rice diet.

Mean intake and absorption of essential amino acids (Table VI) : The amount of essential amino acids absorbed was calculated as amino acid intake × digestibility coefficient ÷ 100 on the assumption that all the amino acids were digested and absorbed to the same extent. The results show that the amount of different amino acids absorbed from the rice diet and rice-protein food diet met the requirements according to FAO[4] or the ideal reference protein pattern suggested by Swaminathan.[5] The amount of different amino acids absorbed from the different diets also met the amino acid requirements of children reported by Nakagawa *et al.*[9–11]

Discussion

The results presented in Table VII show that the net available protein per kg body weight from the rice diet (1.04g) was equal to the FAO reference protein requirements (1.05) and higher than the Ideal reference protein requirements (0.95g) for girls aged 9-10 years. According to Platt *et al*,[8] the protein requirements of girls aged 9-10 years, recommended by FAO is 6.2 when expressed as ND-p Cals %. This figure is higher than the ND-p Cals% of 5.87 obtained in this study for rice diet. The ND-p Cals % obtained for the rice-protein food diet (7.61) is, however, higher than that (6.2) required to meet the protein requirements of the children. In view of the difficulties in assessing accurately the calorie requirements of children, it may

Table IV. *Digestibility coefficient and biological value of proteins of the rice diet and rice-protein food diet consumed by the children*

Diet		Nitrogen intake (g/day)	Nitrogen excretion (g/day)		True digestibility %	Biological value
Description	Calorie value (K cal/day)		Urinary	Faecal		
Rice	1530	6.35	3.23	1.63	85.5	65.1
Rice-Protein Food	1531	9.13	5.28	1.51	91.8	55.6
Standard error of the mean (7df)					±1.2	±0.9

Table V. *Mean value for net protein utilization, net dietary protein value and net dietary protein calories of the rice diet and rice-protein food diet consumed by children.*

Diet	Daily protein intake		Protein in diet %	Protein calories %	NPU (op)	ND-p Cals %	ND-pv %	Net available protein	
	g	g/kg body weight						g/day	g/kg body weight day
Rice	39.7	1.87	10.52	10.38	55.8	5.80	5.87	22.2	1.04
Rice-protein food	57.1	2.72	15.32	14.91	51.0	7.61	7.81	29.1	1.39
Standard error of the mean (7 df)					±1.1	±0.14			

Table VI. *Mean daily intake (g) and absorption[2] of essential amino acids from the rice diet and rice-protein food diet consumed by the children*

Amino acid	Rice diet		Rice-protein food diet		FAO reference protein requirements[3]	Ideal reference protein requirements[4]	Minimum daily amino acid requirements[5]
	Intake	Absorption	Intake	Absorption			
Arginine	2.10	1.80	3.85	3.57	—	1.32	—
Histidine	0.79	0.68	1.26	1.16	—	0.48	—
Lysine	1.77	1.48[1]	3.12	2.90	0.93	1.50	1.26
Tryptophan	0.41	0.35	0.64	0.59	0.31	0.32	0.19
Phenylalanine	2.11	1.80	3.03	2.78	0.62	1.16	0.57
Methionine	0.66	0.57	1.29	1.21	0.49	0.56	0.57
Cystine	0.58	0.49	0.89	0.81	—	0.40	—
Total S-amino acids	1.24	1.06	2.18	2.02	0.93	0.96	0.57
Threonine	1.39	1.19	2.09	1.93	0.62	1.00	0.74
Leucine	2.90	2.48	4.12	3.79	1.06	2.00	0.94
Iso-leucine	1.89	1.61	2.76	2.53	0.93	1.32	0.63
Valine	2.19	1.87	3.08	2.82	0.93	1.40	0.69

[1] The limiting amino acid as compared to ideal reference protein
[2] Calculated as intake × digestibility coefficient of the protein ÷ 100
[3] The reference protein requirements of children calculated according to FAO amount to 23.7g
[4] The ideal reference protein requirements of children calculated according to Swaminathan amount to 21.0g.
[5] After Nakagawa *et al.*[9-11]

Table VII. *Net available protein from rice diet and rice-protein food diet as compared with minimum protein requirements*

	Net available protein (g/kg body wt)
Rice diet	1.04
Rice-Protein food diet	1.39
FAO reference protein requirements	1.05
Ideal reference protein requirements	0.95
Protein requirements in terms of egg and milk protein to meet amino acid requirements—	
Egg protein	0.90
Cow's milk protein	0.90

be preferable to express the protein requirements in terms of net available protein as g per kg body weight. The net available protein per kg body weight from the rice diet (1.04g) is equal or higher than the protein requirements of the children according to FAO (1.05g) or the Ideal reference protein (0.95g) requirements. It is of interest to note from the results presented in Table VI, that the amount of amino acids absorbed from the rice-diet are higher than the amino acid requirements of the children reported by Nakagawa *et al.*[9-10] The results indicate that the rice diet provided the minimum protein and amino acid requirements of the children. However, since supplementation of the rice-diet with a protein food based on a blend of soya and groundnut flours and fortified with lysine and methionine, promoted higher growth in the children and caused significantly higher retention of nitrogen, it may be concluded that the rice diet did not provide the optimum amounts of protein for promoting normal growth in children.

Summary

1. The effect of supplementing a poor Indian rice diet daily, with 40g of protein food based on a 1 : 1 blend of full-fat soya and groundnut flours and fortified with 1% each of l-lysine and dl-methionine and adequate amounts of essential vitamins and minerals (so as to provide about 20g extra protein daily) on the biological value and net protein utilization was studied in 8 pairs of girls aged 9-10 years.

2. The true digestibility coefficient of the mixed proteins of rice-protein food diet (91.8) was significantly higher than that (85.5) observed for the rice diet. The biological value of the proteins of the rice diet (65.1) is, however, significantly higher than that (55.6) of the rice-protein food

diet. This may be due to the fact that the protein content of the rice-protein food diet (15.32%) was higher than that (10.52%) of the rice diet.

3. The NPU (op) of the rice diet supplemented with the protein food (51.0) was lower than that (55 8) of rice diet, The ND-p Cals% of the rice-protein food diet (7.61) was, however, significantly higher than that (5.80) of the rice diet. The net available protein per kg body weight from the rice diet (1.04g) was equal to the FAO reference protein requirements (1.05g) but lower than that (1·39g) from the rice-protein food diet.

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