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THE DIGESTIBILITY COEFFICIENT, BIOLOGICAL VALUE AND NET UTILIZATION OF THE PROTEINS OF FISH FLOUR FROM OIL SARDINE (CLUPEA LONGICEPS) IN CHILDREN

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The wide prevalance of malnutrition among children in tropical and sub-tropical countries has been well established during recent years.[1] Its prevention depends on increasing the production and availability of protein-rich foods in these regions. The important sources of protein-rich foods available in the above mentioned countries are oilseeds, oilseed meals, legumes and fish.[2,3] The nutritive value of the proteins of fish is of the same order as that of milk proteins and higher than those of the proteins of oilseeds and legumes.[4] In an earlier publication from this laboratory, the results of studies on the preparation and nutritive value of fish flour (from oil sardine) and a protein food (based on 2 : 1 : 1 blend of groundnut flour, Bengal gram flour and fish flour) were reported.[5-9] The present paper describes the results obtained with children on the digestibility coefficient, biological value and net protein utilization of the proteins of fish flour from oil sardine.

Experimental

Materials: The fish flour used in the present study was prepared according to the process described by Lahiry *et al.*[10] The amino acid composition of the proteins was determined according to Krishnamurthy *et al.*[11]

Metabolic study: The experiment was carried out in a boarding home in Mysore. The subjects were 8 boys. Data regarding their ages, height and weight are given in Table I. The metabolic study was divided into two periods: period 1, fish flour diet and period 2, low protein diet. The children were given rest for one week between the metabolism periods, during which they were fed on the diet usually consumed by them in the boarding home. The composition of the diets is given in Table II. The nutrients supplied by the low-protein and fish flour diets consumed by the children are given in Table III.

The nitrogen contents of the diets, urine and faeces were determined by the micro-kjeldhal method. The true digestibility

Table I. *Ages, heights and weights of the children at the beginning of the test*

Boy	Age (years)	Height (cm)	Weight (kg)
1	11	143	29.5
2	12	143	28.6
3	12	141	27.2
4	11	137	27.2
5	11	137	29.2
6	10	135	27.2
7	11	133	27.2
8	10	128	26.5

Table II. *Mean daily intake (g) of foodstuffs by the children on the low-protein and fish flour diets*

Foodstuffs	Low-protein diet	Fish flour diet
Tapioca corn starch blend*	250	250
Corn starch	34	34
Cane sugar	65	43
Groundnut oil	63	53
Common salt	12	12
Tamarind fruit pulp	5	5
Coconut kernel	7	7
Condiments (red chillies, coriander seeds, fenugreek and turmeric)	8	8
Vegetables (brinjal, tomato, cucumber and onion)	100	100
Fish flour	—	50

* Tapioca corn starch blend (1 : 1) was fortified with minerals and vitamins to provide the daily requirements as recommended by the National Research Council, Food and Nutrition Board (U.S.A.), 1958.

Table III. *Mean daily intake of nutrients by the children on the low-protein and fish flour diets*

Nutrients	Low-protein diet	Fish flour diet
Protein (N×6.25) (g)	3.6	44.4
Fat (g)	66.8	56.8
Carbohydrate (g)	318.2	300.0
Calcium (mg)	1057	1057
Phosphorus (mg)	1373	1373
Iron (mg)	15.1	15.1
Vitamin A (I.U.)	3750	3750
Vitamin D (I.U.)	500	500
Thiamine (mg)	1.4	1.4
Riboflavin (mg)	1.8	1.8
Nicotinic acid (mg)	11.4	11.4
Ascorbic acid (mg)	47.0	47.0

coefficient, biological value, net protein utilization (NPU-op), net dietary protein value (ND-pv) and net dietary protein calories % (ND-p Cals %) were calculated according to the formulae used by Shurpalekar *et al.*[12]

Results

Essential amino acid composition and protein score : The essential amino acid composition of fish flour proteins and their protein scores calculated as compared with FAO reference protein pattern[13] and ideal reference protein pattern suggested by Swaminathan[14] are given in Table IV.

Endogenous urinary and faecal nitrogen (Table V): The mean daily excretions of urinary and faecal nitrogen on the low-protein diet were 1 24 and 0.94 g. respectively.

Nitrogen balance, digestibility coefficient, biological value and net protein utilization of the proteins (*Tables VI & VII*): The mean daily intake and balance of nitrogen on the fish flour diet were 7.1 and 1.87-g. respectively. The true digestibility coefficient, biological value and net protein utilization of the fish flour proteins were 88.8, 64.2 and 57.0 respectively. The ND-pv and ND-p Cals % of the diet were 5.2 and 5.4 respectively.

Mean intake and absorption of essential amino acids (Table VIII): The quantity of essential amino acids absorbed was calculated as amino acid intake × true digestibility coefficient of the protein ÷ 100, on the assumption that all amino acids were digested and absorbed to the same extent. The results show that the amounts of different essential amino acids absorbed from the fish flour diet met the requirements according to FAO[13], the ideal reference protein pattern suggested by

Table IV. *Essential amino acid content (g/16g N) of the proteins of fish flour diet*

Amino acid	Fish flour diet	FAO reference protein	Ideal reference protein
Arginine	5.6	—	6.6
Histidine	2.7	—	2.4
Lysine	9.2	4.2	7.5
Leucine	7.1	4.8	10.0
Isoleucine	5.1	4.2	6.6
Methionine	2.6	2.2	2.8
Cystine	1.4	—	2.0
Total sulphur amino acids	4 0	4.2	4.8
Phenylalanine	3.7	2 8	5.8
Tyrosine	2.9	2.8	5.0
Total aromatic amino acids	6.6	5.6	10.8
Threonine	5.6	2.8	5.0
Tryptophan	1.0	1.4	1.6
Valine	5.2	4.2	7.0
Protein scores			
FAO pattern	71	100	—
Ideal reference pattern	63	—	100

Table V. *Daily urinary and faecal excretion (g) of nitrogen by the children on the low-protein diet*

Boy no.	Urinary	Faecal	Total
1	0.91	0.65	1.56
2	1.33	0.84	2.17
3	1.53	1.31	2.84
4	1.50	0.80	2.30
5	1.70	1.20	2.90
6	0.98	0.89	1.87
7	1.09	0.86	1.95
8	0.89	0.98	1.87
Mean value with standard error (7 df)	1.24 ± 0.11	0.94 ± 0.06	2.18 ± 0 17

Table VI. *Mean daily balance of nitrogen and digestibility coefficient and biological value of the proteins of fish flour consumed by the children*

Calorie intake (Kcal/day)	1888
Nitrogen intake (g)	7.11
Urinary excretion (g)	3.51
Faecal excretion (g)	1.73
Total excretion (g)	5.24
Nitrogen balance (g)	1.87 ± 0.13 (7 df)
True digestibility (%)	88.8 ± 0.89 (7 df)
Biological value (%)	64.2 ± 2 00 (7 df)

Table VII. *Mean values for net protein utilization, net dietary protein value and net dietary protein calories of the fish flour diet consumed by the children*

Daily protein intake (g)	44.4
,, ,, ,, (g/kg body weight)	1.6
Protein in the diet (%)	9.1
Protein calories (%)	9.4
NPU (op) .%)	57.0 ±2.0 (7 df)
Net available protein (g)	25.3
,, ,, (g/kg body weight)	0.91
ND-pv (%)	5.2
ND-p Cals (%)	5.36 ±0.19 (7 df)

Swaminathan[14] and the minimum amino acid requirements of children reported by Nakagawa *et al.*[15-17]

Discussion

The results presented in Table VII show that the 'net available protein' per kilogram body weight from the fish flour diet (0.91g) was nearly equal to the reference protein requirement suggested by FAO (1.05g) and ideal protein requirement (0.92g) suggested by Swaminathan.[14] The results also indicate that the fish flour diet providing about 1.5g of protein per kg body weight met the minimum protein and amino acid requirements of children aged 10—12 years. The recommended allowance for children aged 10-12 years according to the Food and Nutrition Board is 1.96g per kg body weight and a mixed diet providing this amount of protein should adequately meet the protein needs of children of this age group. According to Platt *et al.*,[18] the FAO reference protein requirements of boys aged 10-12 years is about 6.1 when expressed as ND–p Cals %. This figure, however, is higher than the ND–p Cals % of 5.2 observed for fish flour diet. In view of the difficulties in assessing accurately the calorie requirements of children, it may be preferable to express the protein requirements in terms of net available protein (g) per kg body weight, rather than in terms of net dietary protein calories.

Summary

1. The nitrogen retention, true digestibility coefficient, biological value and net protein utilization of the proteins of fish flour from oil sardine were determined in 8 boys aged 10-12 years on a protein intake of about 1.5g per kg body weight.

2. The mean daily N intake was 7.1g and the mean daily N retention was 1.87g (corresponding to about 26 % of nitrogen

Table VIII. *Mean daily intake (g) and absorption[1] by the children of essential amino acids from the fish flour diet*

Amino acid	Fish flour diet		FAO reference protein requirements[2]	Ideal reference protein requirements[3]	Minimum daily amino acid requirements[4]
	Intake	Absorption			
Arginine	2.49	2.21	—	1.69	—
Histidine	1.20	1.07	—	0.61	—
Lysine	4.09	3.63	1.23	1.92	1.67
Tryptophan	0.44	0.39	0.41	0.41	0.25
Methionine	1.16	1.03	0.64	0.72	0.75
Cystine	0.62	0.55	—	0.51	—
Total sulphur amino acids	1.78	1.58	1.23	1.23	—
Phenylalanine	1.64	1.46	0.82	1.48	0.75
Tyrosine	1.29	1.15	0.82	1.28	—
Total aromatic amino acids	2.93	2.61	1.64	2.76	—
Threonine	2.49	2.21	0.81	1.28	0.97
Leucine	3.16	2.81	1.40	2.56	1.25
Isoleucine	2.27	2.02	1.23	1.69	0.83
Valine	2.31	2.05	1.23	1.79	0.92

1. Calculated as intake × digestibility coefficient of the protein ÷ 100
2. The reference protein requirements of the children calculated according to FAO[18] amount to 29.2g.
3. The ideal reference protein requirements of children calculated according to Swaminathan[14] amount to 25.6 g.
4. After Nakagawa *et al* [16-17]

intake). The true digestibility coefficient, biological value and net protein utilization of the fish flour proteins were 88.8, 64.2 and 57.0 respectively. The net dietary protein value and net dietary protein calories percent of the diet were 5.2 and 5.4 respectively. The net available protein per kg body weight from the fish flour diet (0.91g) was nearly equal to the FAO reference protein requirement (1.05g).

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