

4. The diaminopimelic acid present in the microbial fraction has also been used to differentiate the bacterial nitrogen from the protozoal nitrogen.

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## The metabolism of nitrogen, calcium and phosphorus in undernourished children

### 4.\* The effect of replacing rice in the diet by tapioca macaroni on the metabolism of nitrogen, calcium and phosphorus

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In a previous publication from this laboratory, Murthy, Reddy Swaminathan & Subrahmanyam (1955) reported that undernourished children subsisting on an inadequate and ill-balanced diet grew at subnormal rate but maintained on an average slightly positive nitrogen, calcium and phosphorus balances. In a recent publication, Subrahmanyam, Bhagawan, Doraiswamy, Joseph, Bains, Bhatia, Sankaran & Swaminathan (1958) found that replacement of rice in the diet of such undernourished children by tapioca macaroni (composed of 60 parts of tapioca flour, 15 parts of low-fat groundnut flour and 25 parts of wheat semolina) for a period of 6 months did not cause any deterioration in the general health, nutritional status and growth of the children. The present paper deals with studies on the effect of replacing rice by tapioca macaroni on the metabolism of N, Ca<sup>+</sup> and P.

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## METHODS

*Subjects.* The investigation was carried out when the feeding experiment with tapioca macaroni (Subrahmanyam *et al.* 1958) had been in progress for a period of 3 months. Five pairs of children aged 9–11 years were selected from among the subjects of the feeding experiments for the metabolic study. The girls of each pair were similar in age, weight and height (Table 1). They had been clinically examined and found free from ailments likely to interfere with the experiment.

Table 1. *Age, height and weight of the children at the beginning of the metabolic experiment*

Child no.	Age (years)	Height (in.)	Weight (lb.)
Rice diet			
1	11	51·6	53·0
2	11	47·9	45·0
3	10	47·0	41·0
4	9	47·4	42·8
5	9	43·3	37·8
Tapioca-macaroni diet			
6	11	52·4	51·5
7	11	48·4	45·5
8	10	47·7	44·5
9	9	46·8	45·8
10	9	43·4	41·0

*Experimental diets and feeding of the children.* The composition of the diets taken by the subjects during the metabolic experiments was the same as during the feeding study (Subrahmanyam *et al.* 1958). The pattern of breakfast, lunch and dinner was also the same. The method adopted for feeding the subjects was similar to that described by Murthy *et al.* (1955). The quantity of foods consumed daily by the children was recorded throughout the experimental period. Complete duplicates of all dishes consumed by each subject were collected daily, dried in an air oven at 80–90° and weighed. They were powdered and analysed for their N, Ca and P content.

*Plan of the experiment.* The experimental period lasted 7 days. During the first 2 days, the children were left to become accustomed to the equipment used for the collection of urine and faeces, which were collected only during the next 5 days. The methods used for collecting and preserving the urine and faeces have been described by Murthy, Swaminathan & Subrahmanyam (1954).

*Analytical methods.* The methods for the estimation of N, Ca and P in food, urine and faeces were the same as those described by Murthy *et al.* (1954).<sup>1</sup> All the analyses were carried out in duplicate.

## RESULTS

The results for N, Ca and P metabolism are given in Table 2.

The mean daily intake of calories, protein and Ca on the rice diet and the tapioca-macaroni diet fell short of the recommended allowances suggested by the Indian

Council of Medical Research: Nutrition Advisory Committee (1944). The intakes of protein, Ca and P by the subjects on the two diets were slightly lower than the corresponding mean intakes reported by Subrahmanyam *et al.* (1958). The differences were due to the fact that the values for protein, Ca and P in the diets consumed by the subjects were determined by actual analysis, whereas the values reported by Subrahmanyam *et al.* (1958) were obtained by calculation from the figures given by Aykroyd, Patwardhan & Ranganathan (1956) for the nutritive value of Indian foods.

Table 2. Mean daily intake, excretion and balance of nitrogen, calcium and phosphorus of children on the rice diet and tapioca-macaroni diet

Diet	Intake	Excretion			Balance
		Urinary	Faecal	Total	
		Nitrogen (g)			
Rice (control)*	4.528	2.599	1.143	3.742	0.786
Tapioca macaroni† (experimental)	6.240	3.834	1.465	5.299	0.941
Difference (experimental - control)	1.712	1.235	0.322	1.557	0.155 ± 0.170‡
		Calcium (mg)			
Rice (control)*	285.2	65.9	190.8	256.7	28.5
Tapioca macaroni† (experimental)	380.1	50.3	236.5	286.8	93.3
Difference (experimental - control)	94.9	-15.6	45.7	30.1	64.8 ± 18.5‡
		Phosphorus (mg)			
Rice (control)*	546.8	192.3	271.1	463.4	83.4
Tapioca macaroni† (experimental)	562.4	181.0	274.7	455.7	106.6
Difference (experimental - control)	15.6	-11.3	3.6	-7.7	23.2 ± 10.6‡

\* Calorie intake: 1121 Cal./child/day.

† Calorie intake: 1130 Cal./child/day.

‡ Value with its standard error.

*Nitrogen metabolism.* The mean daily intakes of N on the rice diet and on the tapioca-macaroni diet were 4.53 and 6.24 g, respectively. The mean daily excretions in the faeces and urine were slightly lower in the children fed on the rice than in those fed on the tapioca-macaroni diet (3.70 and 5.30 g, respectively). All the subjects on both diets were in positive balance. The mean daily retentions on the rice diet and tapioca-macaroni diet were 0.786 and 0.941 g, the difference being not statistically significant.

*Calcium metabolism.* All the children on both diets were in positive balance. The mean daily intakes on the rice diet and tapioca-macaroni diet were 285.2 and 380.1 mg, respectively. The mean daily retentions were 28.5 and 93.3 mg, respectively. The difference in the mean daily retention, though large, was not statistically significant.

*Phosphorus metabolism.* The mean intakes on the rice diet and tapioca-macaroni diet were 546.8 and 562.4 mg, respectively. All the subjects in the two groups were in positive balance. The mean daily retention on the tapioca-macaroni diet (106.6 mg) was appreciably greater than that on the rice diet (83.4 mg), the difference, however, being not statistically significant.

## DISCUSSION

It is evident from the results that complete replacement of rice in a poor vegetarian diet by an equal quantity of tapioca macaroni brought about an apparently appreciable, but not significant, increase in the retention of N, Ca and P by children. The mean daily calorie intake of the experimental subjects was only 1120 Cal. This value is low compared with the recommended allowance of 1850 Cal. for children of this age group (Aykroyd *et al.* 1956). Nevertheless, all the experimental subjects maintained positive N, Ca and P balance.

The results obtained in the present and earlier studies are of great significance to regions producing large amounts of tapioca, namely Kerala State in India, certain parts of Africa, South America and Asia. In these regions, production and consumption of tapioca macaroni in place of tapioca will help considerably in improving the nutritional status of the people and in overcoming the shortage of rice and other food grains.

## SUMMARY

1. The metabolism of nitrogen, calcium and phosphorus was studied during 5 days in five pairs of girls aged 9–11 years, similar in age, height and weight and fed on an inadequate poor vegetarian diet based either on rice or on tapioca macaroni composed of tapioca flour (60 parts), low-fat groundnut flour (15 parts) and semolina (25 parts).

2. The mean daily N intakes on the rice diet and on the tapioca-macaroni diet were 4.53 and 6.24 g, respectively. All the children maintained positive balance. The daily retentions of N on the tapioca-macaroni diet and on the rice diet were 0.94 and 0.79 g, respectively, the difference being not significant.

3. The mean daily intakes of Ca on the rice diet and on the tapioca-macaroni diet were 285.2 and 380.1 mg, respectively. All the children were in positive balance. The mean daily retention of Ca on the tapioca-macaroni diet (93.3 mg) was larger than that on the rice diet (28.5 mg), the difference, however, being not significant.

4. The mean daily intakes of P on the rice diet and on the tapioca-macaroni diet were 546.8 and 562.4 mg, respectively. All the children were in positive balance. The mean daily retentions of P on the two diets were 83.4 and 106.6 mg, respectively, the difference being not significant.

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