

- League of Nations Health Organization (1932). *Quart. Bull. Hlth Org. L.o.N.* **1**, 479.
- Nandi, D. K., Rajagopalan, R. & De, S.S. (1953). *Indian J. Physiol.* **7**, 1.
- National Research Council: Food and Nutrition Board (1948). *Repr. nat. Res. Coun., Wash.*, no. 129, p. 13.
- Patwardhan, V. N. (1952). *Nutrition in India*, 1st ed. Bombay: Indian Journal of Medical Sciences.
- Reddy, S. K., Doraiswamy, T. R., Sankaran, A. N., Swaminathan, M. & Subrahmanyam, V. (1954). *Brit. J. Nutr.* **8**, 17.
- Subrahmanyam, V., Ramarao, G., Kuppaswamy, C., Narayanarao, M. & Swaminathan, M. (1957). *Food Sci.* **6**, 76.
- Subrahmanyam, V., Reddy, S. K., Moorjani, M. N., Sur, G., Doraiswamy, T. R., Sankaran, A. N., Bhatia, D. S. & Swaminathan, M. (1954). *Brit. J. Nutr.* **8**, 348.

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

### 3\*. The effect of a supplementary multipurpose food on the metabolism of nitrogen, calcium and phosphorus

BY KANTHA JOSEPH, M. NARAYANARAO, M. SWAMINATHAN  
AND V. SUBRAHMANYAN

*Central Food Technological Research Institute, Mysore, India*

(Received 4 April 1957)

In a previous publication from this laboratory, Murthy, Reddy, Swaminathan & Subrahmanyam (1955) reported that undernourished children subsisting on an inadequate and ill-balanced vegetarian diet grew at a subnormal rate, but showed a remarkable adaptation to low levels of intake, maintaining on average slightly positive nitrogen, calcium and phosphorus balances. In further investigations, Subrahmanyam, Reddy, Moorjani, Sur, Doraiswamy, Sankaran, Bhatia & Swaminathan (1954) and Sur, Reddy, Swaminathan & Subrahmanyam (1955) found that supplementation of the diet of such undernourished children with 12 oz. daily of groundnut milk curds, significantly increased growth and nutritional status and also the retention of N, Ca, and P. Subrahmanyam, Joseph, Doraiswamy, Narayanarao, Sankaran & Swaminathan (1957) reported that a supplement of 2 oz. daily of a multipurpose food (MPF) (composed of groundnut flour and Bengal-gram flour and fortified with certain vitamins and calcium phosphate) for a period of 5 months produced a marked improvement in the growth and nutritional status of such children. This paper deals with studies on the effect of the multipurpose-food supplement on the metabolism of N, Ca and P.

#### METHODS

*Subjects.* The investigation was carried out when the institutional feeding experiment with multipurpose food (Subrahmanyam *et al.* 1957) had been in progress for a period of 3 months. Five pairs of children aged 8–11 years were selected from among

\* Paper no. 2: *Brit. J. Nutr.* (1955), **9**, 210.

the subjects (girls) of the feeding experiment for the metabolic study. The girls of each pair were similar in age, weight and height (Table 1). They had been examined clinically and found free from disease likely to interfere with the experiment.

*Experimental diets and feeding of the children.* The mean composition of the diets consumed by the experimental subjects during the metabolic experiments was the same as that given during the feeding experiment except that the consumption of rice was slightly less. The pattern of breakfast, lunch and dinner was that reported by Subrahmanyam *et al.* (1957). The method adopted for feeding the subjects was similar to that described by Murthy *et al.* (1955). The foods consumed daily by the children were recorded throughout the experimental period. Complete duplicates of all dishes consumed by each subject were collected daily, dried in an air oven and weighed. They were powdered and analysed for their N, Ca and P content.

Table 1. *Ages, heights and weights of the experimental children on the rice diet and on the rice-multipurpose-food diet at the beginning of the metabolic experiment*

Child no.	Age (years)	Height (in.)	Weight (lb.)
Rice diet			
1	10	48.2	46.4
2	10	46.8	42.4
3	9	46.6	38.9
4	8	41.2	35.2
5	10	44.5	39.1
Rice-MPF diet			
6	10	49.4	51.0
7	10	47.3	44.4
8	9	47.0	44.4
9	8	42.7	35.5
10	10	44.3	38.0

*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 total N, Ca and P in food, urine and faeces were those described by Murthy *et al.* (1954). 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, Ca and P on the control rice diet fell short of the recommended allowances suggested by the Indian Council of Medical Research: Nutrition Advisory Committee (1944). It will also be observed that the intakes of calories, protein and P in the two groups were slightly lower than the corresponding mean intakes reported by Subrahmanyam *et al.* (1957). The differences were due to the fact that the children selected for the metabolic study consumed on

the average less rice (133.4 g daily) than the average consumed by all the children in the orphanage (174.7 g daily). Further, 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.* (1957) were obtained from the figures given by Aykroyd, Patwardhan & Ranganathan (1956) for the nutritive value of Indian foods.

*Nitrogen metabolism.* The mean daily intakes on the rice diet and on the rice-MPF diet were 2.96 and 6.09 g respectively. The mean excretion in the faeces was slightly higher (1.20 g) for the children fed on the rice-MPF diet than for those fed on the rice diet (0.70 g). The loss in the urine was appreciably greater on the rice-MPF diet than on the rice diet. All the subjects on both the diets were in positive balance. The mean daily retentions on the rice diet and on the rice-MPF diet were 0.453 and 0.962 g respectively, the difference being significant at the 5% level.

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

Diet	Intake	Excretion			Balance
		Urinary	Faecal	Total	
		Nitrogen (g)			
Rice (control)*	2.961	1.806	0.702	2.508	0.453
Rice-MPF (experimental)†	6.089	3.926	1.201	5.127	0.962
Difference	3.128	2.120	0.499	2.619	0.509 ± 0.188‡
		Calcium (mg)			
Rice (control)*	287.2	78.8	155.0	233.8	53.4
Rice-MPF (experimental)†	565.6	160.2	210.9	371.1	194.5
Difference	278.4	81.4	55.9	137.3	141.1 ± 48.6‡
		Phosphorus (mg)			
Rice (control)*	421.4	145.5	199.5	345.1	76.3
Rice-MPF (experimental)†	796.6	243.1	389.4	632.5	164.1
Difference	375.2	97.6	189.9	287.4	87.8 ± 31.3‡

\* Calorie intake: 1060 Cal./child/day.

† Calorie intake: 1049 Cal./child/day.

‡ Value with its standard error.

*Calcium metabolism.* All the children on both diets were in positive balance. The mean daily intakes on the rice diet and on the rice-MPF diet were 287.2 and 565.6 mg respectively. The mean daily retentions were 53.4 and 194.5 mg respectively, the difference being significant at the 5% level.

*Phosphorus metabolism.* The mean intakes on the rice diet and on the rice-MPF diet were 421.4 and 796.6 mg respectively. All the subjects in the two groups were in positive balance. The mean daily retention on the rice-MPF diet (164.1 mg) was appreciably greater than that on the rice diet (76.3 mg), the difference being significant at the 5% level.

#### DISCUSSION

It is evident from the results that supplementation of a poor vegetarian rice diet with 2 oz. of a multipurpose food daily brought about a significant increase in the retention of N, Ca and P. The mean daily calorie intake of the experimental subjects was only

1060 Cal. This value is low compared with the recommended allowance of 1850 Cal. for children of this age group (Aykroyd *et al.* 1956). In spite of an inadequate calorie intake, the addition of extra protein produced a significant increase in the retention of N. The increase in the retention of Ca, P and N now observed as a result of supplementation with 2 oz. multipurpose food, is of the same order as that found in a previous study with a supplement of 12 oz. vegetable-milk curds (Sur *et al.* 1955). The results obtained in this and an earlier study (Subrahmanyam *et al.* 1957) have clearly indicated the gross inadequacy of the diets consumed by the children in the orphanage and the beneficial effects produced by a daily supplement of 2 oz. multipurpose food. It may be concluded that since protective foods like milk and milk products are scarce and costly, the production and consumption of fortified protein foods like the multipurpose food could help considerably in making up the deficiencies in poor Indian diets and in improving the health and nutritional status of the population.

## SUMMARY

1. The metabolism of nitrogen, calcium and phosphorus was studied during 5 days in five pairs of girls aged 8–11 years, similar in age, height and weight and fed on an inadequate poor vegetarian diet based on rice or on the same diet supplemented daily with 2 oz. of a multipurpose food (MPF) composed of groundnut flour and Bengalgram flour fortified with certain vitamins and calcium phosphate.

2. The mean daily N intakes on the rice diet and on the rice-MPF diet were 2.96 and 6.09 g respectively. All the children in the two groups maintained positive N balance. The daily retention of N on the rice-MPF diet (0.96 g) was significantly higher ( $P < 0.05$ ) than that on the rice diet (0.45 g).

3. The mean daily intakes of Ca on the rice diet and on the rice-MPF diet were 287 and 565 mg respectively. All the children on the two diets were in positive Ca balance. The mean daily retentions of Ca on the rice diet and on the rice-MPF diet were 53 and 194 mg respectively, the difference being significant at the 5% level.

4. The mean daily intakes of P on the rice diet and on the rice-MPF diet were 421 and 796 mg respectively. All the children on the two diets were in positive P balance. The mean daily P retentions on the rice and on the rice-MPF diets were 76 and 164 mg respectively, the difference being statistically significant ( $P < 0.05$ ).

Our thanks are due to Mr A. N. Sankaran for the statistical analysis of the results.

## REFERENCES

- Aykroyd, W. R., Patwardhan, V. N. & Ranganathan, S. (1956). *The Nutritive Value of Indian Foods and the Planning of Satisfactory Diets*, 5th ed. Delhi: Manager of publications.
- Indian Council of Medical Research: Nutrition Advisory Committee (1944). *Report of the Scientific Advisory Board for the year 1944*. Delhi: Indian Council of Medical Research.
- Murthy, H. B. N., Reddy, S. K., Swaminathan, M. & Subrahmanyam, V. (1955). *Brit. J. Nutr.* **9**, 203.
- Murthy, H. B. N., Swaminathan, M. & Subrahmanyam, V. (1954). *Brit. J. Nutr.* **8**, 11.
- Subrahmanyam, V., Joseph, K., Doraiswamy, T. R., Narayanarao, M., Sankaran, A. N. & Swaminathan, M. (1957). *Brit. J. Nutr.* **11**, 382.
- Subrahmanyam, V., Reddy, S. K., Moorjani, M. N., Sur, G., Doraiswamy, T. R., Sankaran, A. N., Bhatia, D. S. & Swaminathan, M. (1954). *Brit. J. Nutr.* **8**, 348.
- Sur, G., Reddy, S. K., Swaminathan, M. & Subrahmanyam, V. (1955). *Brit. J. Nutr.* **9**, 210.