The effect of a supplementary multipurpose food on the growth and nutritional status of schoolchildren

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Dietary and clinical surveys carried out in India, Africa and in several countries elsewhere, in Asia and South America, have shown that the diets of large numbers of people are deficient in many essential nutrients such as proteins, vitamins and minerals (Patwardhan, 1952; Autret & Behar, 1954; Gopalan & Ramalingaswami, 1955; Brock & Autret, 1952). Protective foods such as milk, eggs, fish and meat are not available in sufficient quantities in these countries and the prospects of increasing their production in the near future are poor (Autret & van Veen, 1955). Considerable attention has recently been devoted to evolving supplementary foods from indigenous resources for improving the health of the vulnerable groups of the population (Autret & van Veen, 1955).

Various attempts have been made in India and other countries to prepare palatable milk substitutes from soya beans, groundnuts and other raw materials (Dean, 1953; De & Subrahmanyan, 1945; Nandi, Rajagopalan & De, 1953). Feeding experiments carried out on infants and children have shown that such foods possess a marked supplementary value to their ordinary diet (Dean, 1953; Subrahmanyan, Reddy, Moorjani, Sur, Doraiswamy, Sankaran, Bhatia & Swaminathan, 1954). Other processed food products which appear to have immense possibilities for large-scale use in combating malnutrition are the multipurpose foods prepared by suitable processing of expeller soya-bean or groundnut cakes and fortifying with essential vitamins and minerals (Cooper & Bryan, 1951; Subrahmanyan, Ramarao, Kuppuswamy, Narayanarao & Swaminathan, 1957). The multipurpose food prepared by the Meals for Millions Foundation, Los Angeles, U.S.A., has been reported to be a good supplement to the diets of schoolchildren (Cooper & Bryan, 1951). Investigations carried out recently in the Central Food Technological Research Institute, Mysore, have shown that a multipurpose food prepared from a blend of low-fat groundnut flour and Bengal-gram flour and fortified with essential vitamins and minerals possesses a marked supplementary value for poor Indian diets as determined by studies on albino rats (Joseph, Narayanarao, Swaminathan & Subrahmanyan, 1957; Kuppuswamy, Joseph, Narayanarao, Ramarao, Swaminathan & Subrahmanyan, 1957*a*, *b*). The present paper describes studies on the value of the multipurpose food as a supplement to the diet of children.

METHODS

Preparation of the multipurpose food. The multipurpose food used in the investigation was prepared according to the method described by Subrahmanyan *et al.* (1957) by blending a mixture of groundnut-cake grits (75 parts) and roasted Bengal-gram grits (25 parts) and fortifying with thiamine, riboflavin, vitamins A and D and calcium phosphate. The product was suitably seasoned with salt, spices and dry onion powder. Of this preparation 2 oz. were given daily to children; the different nutrients present in this amount are shown in Table 1.

Table 1. *Nutrients in 2 oz. (56·8 g) multipurpose food*

Nutrient	Amount
Protein (nitrogen × 6·25) (g)	20·6
Fat (g)	4·0
Carbohydrate (g)	25·4
Calcium (mg)	280
Phosphorus (mg)	370
Iron (mg)	5·4
Thiamine (mg)	0·8
Riboflavin (mg)	1·7
Nicotinic acid (mg)	7·9
Vitamin A (i.u.)	1704
Vitamin D (i.u.)	170
Calories (Cal.)	220

Subjects. The investigation was carried out in an orphanage containing about ninety girls ranging in age from 4 to 15 years. Clinical examination was made of all the girls below 12 years. Forty-six girls aged 4–12 years, free from diseases likely to interfere with the experiment, were selected as experimental subjects. The children were treated for worms by the administration of santonin 2 weeks before the beginning of the experiment.

Physical measurements and assessment of nutritional status. Height, weight, nutritional status, red blood cell counts and haemoglobin content of the blood were determined according to the methods described in an earlier paper (Reddy, Doraiswamy, Sankaran, Swaminathan & Subrahmanyan, 1954). Height was recorded to the nearest $\frac{1}{8}$ in. and weight to the nearest $\frac{1}{8}$ lb. On the basis of initial height and weight, the children were paired and the members of each pair allotted at random to two groups.

Composition of experimental diets and feeding of children. A dietary survey was carried out in the same way as described in an earlier paper (Reddy *et al.* 1954). The pattern of the diets consumed by the two groups is given in Table 2. The nutritive value of the diets consumed was calculated according to the figures given by Aykroyd, Patwardhan & Ranganathan (1956). The results, together with the dietary requirements suggested by the Indian Council of Medical Research: Nutrition Advisory Committee (1944) for children of similar age, are given in Table 3.

The subjects were fed three times a day. The pattern of breakfast, lunch and dinner was similar to that described by Reddy *et al.* (1954). In addition to the orphanage diet, each subject in the experimental group was given a daily supplement of 2 oz.

multipurpose food; 1 oz. in the form of chutney with lunch and 1 oz. in the form of soup with dinner. In order to equalize the calorie intake in the two groups, each subject in the control group was given daily 1 oz. maize starch and 1 oz. sugar added to pudding. The pudding was served with lunch and dinner. All the subjects relished the supplements and none complained of any digestive trouble during the

Table 2. *Diets consumed by the children*

Food	Intake (g/child/day)
Basal diet common to both groups (rice diet)	
Rice, raw milled	173·8
Ragi (*Eleusine coracana*)	19·3
Wheat flour (as white bread)	34·9
Pulses (Bengal-gram dhal (*Cicer arietinum*) and horse gram (*Dolichos biflorus*))	15·3
Oil (American butter oil)	4·3
Common salt	9·1
Tamarind (*Tamarindus indicus*) pulp from the fruit	1·1
Condiments (coriander, red chillies, garlic, turmeric)	5·7
Meat	8·5
Vegetables, non-leafy (pumpkins, radishes, tomatoes)	44·3
Vegetables, leafy (amaranth leaves, radish tops)	9·4
Jaggery	19·0
Skim-milk powder	8·6
Supplement	
Control group:	
Maize starch	28·4
Cane sugar	28·4
Experimental group:	
Multipurpose food	56·8

The mean consumption unit for both the groups calculated from the international scale of family co-efficients (League of Nations Health Organization, 1932) was found to be 0·8.

Table 3. *Mean daily intake of different nutrients by the children, compared with standard recommended allowances*

Nutrient	Control group	Experimental group	N.A.C. standard*
Calories (Cal.)	1190	1190	2000
Protein (nitrogen × 6·25) (g)	24·4	45·0	57·0
Fat (g)	8·4	12·4	—
Carbohydrate (g)	255·0	224·0	—
Calcium (g)	0·32	0·60	1–1·5
Phosphorus (g)	0·45	0·82	—
Iron (mg)	8·3	13·7	10–30
Vitamin A:			
As vitamin A (i.u.)	130	1840	3000–4000
As carotene (i.u.)	1160	1160	—
Thiamine (mg)	0·46	1·26	0·5–1·0
Riboflavin (mg)	0·20	1·90	1·8†
Nicotinic acid (mg)	3·4	11·4	12·0†
Ascorbic acid (mg)	13	13	30–50

* Recommendations of the Indian Council of Medical Research: Nutrition Advisory Committee (1944).

† Recommendations of the (U.S.A.) National Research Council: Food and Nutrition Board (1948).

experimental period. The experiment began in July 1956 and lasted for 5 months, at the end of which time the children were again assessed by height, weight, nutritional status, red blood cell count and haemoglobin content of the blood.

RESULTS

The initial and final values for height, weight, haemoglobin level and red blood cell count of the experimental subjects are given in Table 4 and for nutritional status in Table 5.

It will be seen that at the beginning of the experiment, the control and experimental subjects were closely similar. For the purpose of statistical analysis, the increase in the various measurements during the experimental period was obtained for each subject and the mean for each group calculated. The differences in the mean increase between the two groups were tested by the *t* test appropriate for paired comparisons. It will be seen that the increases in height, weight, haemoglobin level and red-cell count were larger in the experimental group than in the control group, the differences being significant at 0·1 % level for the first three, and at 2 % for the red-cell count. Table 5 shows that eighteen children in the experimental group improved in their nutritional status, whereas none in the control group showed improvement. On the other hand, thirteen children in the control group showed deterioration, but none in the experimental group showed any deterioration.

DISCUSSION

It is of interest to compare the results obtained now with those reported by earlier workers who have used other supplementary foods. Aykroyd & Krishnan (1937) observed that a supplement of 1 oz. skim-milk powder providing 10·8 g protein daily significantly improved the growth and nutritional status of schoolchildren subsisting on a poor rice diet. Harris, Weeks & Kinde (1943) reported that supplementation of the diet of children daily with 1 oz. soup powder, prepared from a blend of low-fat groundnut flour, soya flour and skim-milk powder and fortified with vitamins and minerals, significantly improved their nutritional status but not their height and weight. Subrahmanyan *et al.* (1954) reported that supplementation of the diet of children in an orphanage with 12 oz. groundnut curd daily significantly improved the growth and nutritional status of the children. The improvement in the growth and nutritional status now observed with a daily supplement of 2 oz. multipurpose food is almost equal to that reported earlier with a daily supplement of 12 oz. groundnut curds (Subrahmanyan *et al.* 1954). Cooper & Bryan (1951) reported that supplementation of the diet of schoolchildren with 1 oz. daily of an American multipurpose food for a period of 5 months produced a marked increase in weight.

Our results, and those reported by Cooper & Bryan (1951), should be viewed in the light of the widespread incidence of malnutrition among children and other vulnerable groups of the populations of Asian, African and South American countries. In view of the serious shortage of milk and other protective foods in these countries, the large-scale manufacture and distribution of an inexpensive supplementary food like the

Table 4. *Mean values for the initial and final measurements of the children in the control and experimental groups*

(Twenty-three girls in each group)

Character	Control group (*a*)			Experimental group (*b*)			Difference in increase (*b* − *a*)*	Significance of the difference
	Initial value	Final value	Increase	Initial value	Final value	Increase		
Height (in.)	45·83	46·35	0·52	45·66	46·62	0·96	+0·44 ± 0·09 (22 D.F.)	Significant at 0·1 %
Weight (lb.)	41·56	42·56	1·00	41·79	44·40	2·61	+1·61 ± 0·40 (22 D.F.)	Significant at 0·1 %
Haemoglobin (g/100 ml.)	10·62	10·75	0·13	10·77	11·77	1·00	+0·87 ± 0·21 (22 D.F.)	Significant at 0·1 %
Red blood cell count (10^6/mm^3)	4·30	4·37	0·07	4·22	4·55	0·33	+0·26 ± 0·11 (22 D.F.)	Significant at 2 %

* Value with its standard error.

Table 5. *Nutritional status of children in the control and experimental groups*

Nutritional score*	Initial nutritional status of children		Changes in the nutritional status of children					
			Control group, no. of children			Experimental group no. of children		
	Control group, no. of children	Experimental group, no. of children	Improved	Stationary	Deteriorated	Improved	Stationary	Deteriorated
0	0	1	—	—	—	—	1	—
1	1	4	—	—	1	1	3	—
2	1	2	—	1	—	2	—	—
3	4	8	—	1	3	7	1	—
4	5	5	—	2	3	5	—	—
5	5	2	—	1	4	2	—	—
6	4	1	—	2	2	1	—	—
7	3	0	—	3	—	—	—	—
Total	23	23	—	10	13	18	5	—

* According to the recommendation of the Indian Council of Medical Research: Nutrition Advisory Committee (1948).

multipurpose food, prepared from readily-available raw materials such as soya grits, groundnut flour and Bengal-gram flour, will help effectively to combat malnutrition. It is significant that both the FAO and UNICEF have become increasingly interested in the greater use of protein foods other than milk, locally available in the country, in the supplementary feeding of children and other vulnerable groups of the population, and are helping governments through their regular and technical assistance programmes in the production of inexpensive food supplements (Autret & van Veen, 1955).

SUMMARY

1. A feeding experiment extending over a period of 5 months was carried out on forty-six girls aged 4–12 years in an orphanage in Mysore to assess the value of supplementing their poor vegetarian diet with 2 oz. daily of a multipurpose food composed of groundnut flour and Bengal-gram flour, fortified with certain vitamins and calcium phosphate.

2. The children were paired according to initial height and weight and the members of each pair allotted at random to the control and experimental groups.

3. Values for weight, height, nutritional status, haemoglobin level and red-cell count were obtained at the beginning and end of the experiment, for subjects in the control and experimental groups.

4. There was a significant increase in height, weight, red-cell count and haemoglobin levels of the subjects receiving the supplement.

5. Eighteen children in the experimental group improved in nutritional status, whereas none in the control group showed improvement. On the other hand, thirteen children in the control group showed deterioration whereas none in the experimental group showed any.

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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

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In a previous publication from this laboratory, Murthy, Reddy, Swaminathan & Subrahmanyan (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, Subrahmanyan, Reddy, Moorjani, Sur, Doraiswamy, Sankaran, Bhatia & Swaminathan (1954) and Sur, Reddy, Swaminathan & Subrahmanyan (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. Subrahmanyan, 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 (Subrahmanyan *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

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