CHAPTER III

RESULTS AND DISCUSSION

CHAPTER III

RESULTS AND DISCUSSION

As stated earlier, data were obtained on the dietary intake of pre-school children in the village of Raipura. The typical meal consumed by the children in this age group in the lower and upper socio-economic groups and its composition and nutritive value are shown in Tables 13, 14, and 15. It can be seen from the same that the diet of the children belonging to lower socio-economic group was deficient in calories, protein, calcium, vitamin A and riboflavin.

As stated earlier combinations of wheat and bengal gram were evaluated in experiments I and II in order to improve the protein quality of the diet. The results of these experiments are shown in Tables 16 and 17.

It can be seen from the data of Table 16 that a mixture of wheat and bengal gram combined in the ratios 1:1 and 2:1 gave the maximum weight gain and PER. This is to be perhaps expected on the basis of the amino acid composition of the mixture as compared to the FAO reference pattern (Table 18). The addition of bengal gram results not only in an appreciable increase in lysine content, but also in smaller increases in the contents of arginine and histidine which are essential for growth as well as threonine, isoleucine, and valine. The last two increases may be significant in view of the

Table 13: Typical meal consumed by children at home in the different groups studied

Time	Lower class		Upper class	
Morning	Tea	1/2 - 1 cup	Milk	1/2 - 1 cup
	Rotla or	1/4 - 1/2	Bread or	2 - 4 slices
	Roti	1 - 2	Roti	1 - 2
Noon	Khichri or	1/4 - 1/2 serving	Khichri or	1/4 - 1/2 serving
	Kodri-rice	1/4 - 1/2 "	Poori and rice	1/4 - 1/2 "
	Vegetables	25 - 30 g.	Vegetables	25 - 30 g.
	Liquid dal	25 - 30 g.	Liquid dal	25 - 30 g.
	-		Curd	1/4 - 1 cup
Evening	Tea, snacks occasionally	1/2 - 1 cup	Milk or tea	1/2 - 1 cup
	-		Fruits or nuts or snacks	10 - 20 g.
Night	Rotla or	1/4 - 1/2	Roti or poories	2 - 4
	Roti	1 - 2		
	Cooked vegetables	10 - 20 g.	Cooked vegetables	20 - 30 g.
	Liquid dal	15 - 25 g.	Liquid dal	15 - 25 g.
	-		Milk	1/2 - 1 cup

Table 14. Conversion table used for estimation of raw ingredients in cooked foods

Preparations	Weight (g) of one serving given to pre-school children	Raw ingredients (g) in one serving (a)
<u>Liquid foods</u>		
Tea	150	Milk, 25 + Sugar, 10
Milk	150	Milk, 150
Liquid dal	25	Redgram dal, 5
Curd	50	Milk, 50
<u>Solid foods</u>		
Rotla	75	Bajra, 50
Roti	75	Wheat, 50
Poori	50	Wheat, 25 + Oil, 10
Rice	150	Rice, 40
Khichri	150	Rice, 35, + Redgram dal, 5, Fat, 1/2 tsp.
Vegetable cooked	30	Vegetables, 25 + Oil, 1/2 tsp.

(a) salt, water and spices used in cooking not taken into account.

Table 15. Composition of the diet with regard to foodstuff and nutrients.

(i) Foodstuff*	Amount (g)	
	Lower class	Upper class
Cereals (a)	140	75
Pulses (b)	15	15
Groundnut	Negligible	
Leafy vegetables	5	5
Other vegetables	30	50
Sugar or jaggery	20	40
Milk (buffalo)	50	550
Vegetable oils	10	10
Fruits	Negligible	25
Eggs and Flesh foods	nil	5

(a) Bajra, wheat, rice, kodri (4:2:1:1) in the case of lower class and wheat, rice (8:1) in the case of upper class.

(b) Mostly redgram (Cajanus cajan).

(ii) Nutrients**		
Calories	720	1250
Protein (g)	20	39
Calcium (mg)	250	1200
Iron (mg)	19	13
Vitamin A (I.U.)		
as carotene	590	1000
as preformed vitamin	80	1220
total	670	2220
Thiamine (mg)	0.6	0.7
Riboflavin (mg)	0.4	0.9
Vitamin C (mg)	12.0	30.0

* From the raw foods equivalents of cooked foods using the recipe method.

** Calculated from values given for raw ingredients by Aykroyd, Gopalan and Balasubramanian (1966).

Table 16. Comparative nutritive value of wheat, bengalgram and the two mixed in different proportions to rats*

Diet*	Mean food intake g/rat/week	Protein g/100 g diet	Calcium mg/100g diet	Weight gain(g) during 8 weeks	PER	Hemoglobin g/100 ml blood	Femur calcium mg/bone	Tibia calcium mg/bone
Wheat	69	11.8	256	61±0.77 (58–64)	0.90±0.07 (0.81–1.11)	12.2±0.34 (10.9–13.5)	32±1.3 (27–36)	25±0.65 (22–27)
Bengal-gram	65	20.8	286	95±0.9 (92–98)	1.10±0.09 (0.98–1.2)	13.6±0.14 (13.2–14.5)	38±1.1 (34–43)	29±0.8 (28–30)
Wheat & bengal-gram								
8 : 1	77	12.9	260	99±5.2 (70–114)	1.29±0.05 (1.08–1.45)	13.0±0.32 (11.7–14.2)	34±1.4 (29–38)	27±1.2 (19–30)
4 : 1	75	13.6	262	115±3.4 (106–132)	1.46±0.04 (1.37–1.59)	13.5±0.30 (12.4–14.7)	36±0.87 (32–38)	32±1.4 (25–38)
2 : 1	78	14.7	266	134±4.4 (108–147)	1.60±0.03 (1.43–1.72)	13.4±0.4 (12.4–14.4)	45±1.7 (39–52)	38±1.2 (31–40)
1 : 1	76	16.3	272	140±4.4 (113–152)	1.60±0.03 (1.40–1.72)	13.4±0.31 (12.4–14.4)	45±1.8 (37–54)	38±1.2 (32–43)

* with addition of salt, oil and shark liver oil as specified in table 6. Rats were sacrificed after 8 weeks treatment.

Values are means ± S.E.'s with range shown in parentheses.

Table 17. Effect of addition of groundnut to a wheat, bengalgram mixture on growth rate and body composition of rats.

Components of the diet*	Proportion in which combined	Food intake g/rat/week	Protein g/100 g diet	Calcium mg/100 g diet	Weight gain(g) during 4 weeks	PER	Blood** Hemoglobin g/100 ml	Femur calcium** mg/bone
Wheat and bengalgram	1.1	69	16	272	67±4.7 (46-82)	1.6±0.06 (1.5-1.8)	11.6±0.42 (10.4-12.8)	71±5.0 (53-88)
Wheat, bengalgram and groundnut	1:1:2	64	20	270	74±3.4 (60-83)	1.4±0.04 (1.3-1.5)	11.6±0.5 (10.0-13.7)	66±8.0 (41-87)
Wheat, bengalgram, groundnut and skim milk powder	1:1:2:1/3	63	22	394	81±2.3 (71-86)	1.6±0.08 (1.3-1.8)	11.7±0.38 (10.7-12.8)	83±3.1 (73-92)
Wheat and skim milk powder	4:1	67	17	526	67±2.5 (63-80)	1.5±0.05 (1.4-1.6)	11.2±0.36 (10.5-12.6)	71±4.8 (64-83)

* with addition of salts, oils and shark liver oil as specified in table 6.

**after 13 weeks of treatment.

Values are means ± S.E.'s with range shown in parentheses.

Table 18. Essential aminoacid composition (g/g nitrogen) of the food mixtures*

Food mixture	Arginine	Histidine	Lysine	Tryptophan	Phenylalanine	Cystine	Methionine	Threonine	Leucine	Isoleucine	Valine
FAO reference pattern	-	-	0.27	0.09	0.18	0.13	0.14	0.18	0.31	0.27	0.27
Wheat & bengalgram											
8:1	0.369	0.115	0.207	0.064	0.315	0.136	0.117	0.169	0.410	0.237	0.256
4:1	0.394	0.123	0.253	0.061	0.304	0.134	0.116	0.176	0.410	0.255	0.259
2:1	0.428	0.153	0.318	0.055	0.291	0.130	0.115	0.184	0.410	0.273	0.264
1:1	0.460	0.155	0.370	0.050	0.278	0.127	0.113	0.193	0.410	0.292	0.270
Wheat + bengalgram + groundnut											
1:1:2	0.664	0.165	0.300	0.051	0.291	0.103	0.067	0.197	0.491	0.271	0.250
Wheat + bengalgram + groundnut + skim milk powder											
1:1:2:1/3	0.619	0.165	0.331	0.056	0.298	0.097	0.079	0.021	0.577	0.297	0.275

* Values obtained from the following sources :-

For wheat, bengalgram, ~~and~~ groundnut and FAO pattern from Aykroyd, Gopalan and Balasubramanian (1966).
For skim milk powder from Tasker, Indira, Rao, Indiramma, Swaminathan, Sreenivasan, and Subrahmanyan (1962).

relatively high amount of leucine in wheat, an excess of which inhibits the utilization of these amino acids and may therefore increase their dietary requirement (Harper, Benton, and Elvehjem, 1955; Synderman, Cusworth, Roitman and Holt, 1959; Tannous, Rogers and Harper, 1963). It was decided to choose the former proportion (1:1) in the foods prepared as this gives a higher percentage of protein and along with other components resulted in a diet containing 15% protein calories. At the time of the study, bengal gram was available in fair price shops at nearly the same price as wheat, so that a higher proportion of bengal gram could be used without boosting up the cost. However, if the price structure favours wheat, a combination in the ratio 2:1 might be just as good. Incidentally, the poor people were seldom claiming their bengal gram rations as they considered it a frill item and it was hoped that the liberal use of bengal gram at the centre would educate the parents about substituting bengal gram for part of the wheat in their preparations.

The superior protein value of a wheat, bengal gram mixture as compared to that of either wheat or bengal gram is consistent with the results of previous experiments (Phansalkar, Ramachandran and Patwardhan, 1957; Tambe, 1965) and the amino acid composition of either (Table 18).

The greater amount of calcium in the femur and tibia of animals fed the mixtures is consistent with the increase in lysine which is believed to promote calcium utilization; and improvement in protein quality which may be expected to improve calcium status on the basis of studies carried out previously in this laboratory (Rajalakshmi, R. and Prasannakumari, K. unpublished; Rajalakshmi, R. and Saraswathi, S. unpublished). The small differences in calcium intake cannot be held responsible for the phenomenon as in that case the group fed on bengal gram should show maximum calcification.

As stated earlier, it was considered desirable to add groundnut to the wheat and bengal gram mixture used for making 'conjee' in order to give it a more creamy and acceptable taste and to increase its calorie value. A few drops of corn or cottonseed oil have been added to Laubina (McLaren, 1967), but it was found that fat in the form of groundnut was much more acceptable. Also, groundnut gives more food value for money spent than oil (1 kg. of oil costs Rs.2.70 and gives 9000 calories and no protein whereas 1 kg. of groundnut costs Rs.1.80 and gives 250 g. protein and 5600 calories and 1 kg. of bengal gram costing Rs.2.00 gives 3700 calories and 200 g. of protein). But, as groundnut is deficient in lysine and methionine, an experiment was carried out to investigate whether the addition of groundnut affects adversely the protein quality of a wheat, bengal gram mixture and whether it can be reversed by milk which is rich in methionine. The results of this experiment are presented in Table 17 from which it can be seen that addition of groundnut has no adverse effect on weight gain or calcium content. The small decrease in PER, which must be presumed to be partly due to the higher protein content, can hardly be relevant from the standpoint of practical nutrition for which weight gain is perhaps more relevant. The further addition of skim milk as might be expected, increases the nutritive value of the mixture. Nevertheless it is interesting to note that the wheat, bengal gram, groundnut mixture compare favourably with the wheat, milk powder diet which was used as a standard.

The lack of an adverse effect following the addition of groundnut which might be expected to have an unfavourable effect on aminoacid balance must be attributed to the fact that at higher levels of protein intake, such effects do not operate to the same degree (Fisher, Brush, Shapiro, Wessels, Berdanier, Griminger and Sostman, 1963).

No significant differences are found in the calcium status of animals in the different groups. The greater amounts of femur calcium in this experiment as compared to the previous one is believed to be because of the fact that the animals in this experiment were 5 weeks older at the time of death.

As stated earlier, the feasibility of incorporating lime or lime water in foods was investigated. Preliminary studies showed that incorporation of lime water in non-acid foods destroyed a substantial proportion of the vitamins for a small increase in calcium content (Table 19). Similar results have been reported by Pasricha and Rao (1965). This was therefore dismissed as a poor bargain and the incorporation of lime powder in acid foods attempted. The effects of such addition at different levels, on pH, acceptability calcium and vitamin content are shown in Tables 20 and 21.

The availability of the lime so incorporated in a selected food 'dhokla' served for lunch at the centre was investigated in an animal experiment, the results of which are shown in Tables 22 and 23.

Inspite of equal food intake and weight gain in the three groups, animals fed lime-incorporated 'dhokla' showed a significant superiority over those fed the basal diet with regard to calcium retained per gram of body weight gain as well as bone development and calcification. The radiographs taken also confirmed these findings. (Plates, 1,2, and 3). The somewhat better calcium status of the animals fed lime incorporated 'dhokla' compared to those fed a mixture of salts may be due to lime being converted to calcium lactate when added to 'dhokla' as the acidity of fermented foods has been found to be almost entirely due to the lactic acid formed during fermentation.

Table 19. Effect of addition of lime water on non acid foods on calcium and vitamin content.

Foodstuff	Treatment	Amount of lime water (ml) absorbed per 100 g.	Increase in calcium mg/100 g of dry ingredients	Percentage loss of	
				Thiamine	Riboflavin
Dehusked bengalgram	Steeping in lime water for 8-12 hrs	85	30	33	50
Dehusked peas	Steeping in lime water for 8-12 hrs	100	46	25	47
Rice (Pasricha and Rao, 1965)	Cooking with addition of lime water	60	30	66	56

Table 20. Effect of lime powder incorporation in acid foods on pH, calcium and acceptability.

foodstuff	ingredients	amount (g)	procedure	amount (mg) of lime powder added*	pH	increase (mg) in calcium content	sensory rating
1. Dhokla	Coarsely ground wheat	50	Batter prepared from the two fermented, lime-treated, steamed, cooled, sliced and seasoned.	0	5.0	0	Good
	Bengalgram dal	50		500	6.3	200	Very good
				1500	8.5	600	Not acceptable
2. Idli	Rice (coarsely ground)	67	Batter prepared from the two fermented, lime-treated and steamed.	0	4.7	0	Good
	Blackgram dal (finely ground)	33		450	6.0	180	Good
				1000	8.5	400	Not acceptable
3. Khaman	Bengalgram dal	100	as for dhokla	0	5.2	0	Good
				350	6.5	140	Good
				850	8.5	340	Not acceptable
4. Sambhar (broth) used with rice	Redgram dal	12	Vegetables added to partially cooked dal and the cooking continued. When the mixture is almost cooked, lime treated tamarind juice, salt and seasoning added and the cooking completed.	0	5.0	0	Good
	Vegetables	12		150	6.0	60	Good
	Tamarind	2.5		500	8.5	200	Not acceptable
5. Sour buttermilk	Sour curd	20	The two churned together and treated with lime.	0	4.1	0	Good
	Water	80		280	5.5	112	Good

* Values are per 100g of dry ingredients in the case of items 1, 2 and 3 and on wet weight basis in the case of items 4 and 5.

Table 21. Effect of lime powder incorporation in acid foods on thiamine and riboflavin content.

	Foodstuff	Amount of lime powder added mg/100g	pH	Thiamine µg per 100 g*	Percentage loss	Riboflavin µg/100g*	Percentage loss
1.	Dhokla	0	5.0	422 (410-434)	-	430 (410-450)	-
	"	500	6.3	402 (398-406)	4.7	420 (410-430)	2.3
	"	1500	8.5	326 (301-350)	22	260 (210-290)	39
2.	Idli	0	4.7	490 (477-498)	-	495 (470-510)	-
	"	450	6.0	443 (440-447)	9.5	446 (420-460)	9.9
	"	1000	8.5	303 (280-320)	38	420 (400-460)	25
3.	Khaman	0	5.2	630 (628-632)	-	886 (874-888)	-
	"	350	6.5	617 (615-619)	2.5	818 (816-820)	7.6
	"	850	8.5	445 (420-460)	28	731 (720-740)	17
4.	Sambhar	0	5.6	589 (580-598)	-	746 (739-756)	-
	"	150	6.0	554 (550-558)	5.6	696 (630-702)	6.8
	"	500	8.5	439 (437-441)	25	508 (500-512)	-
5.	Butter milk (curd mixed with water in the ratio)	0	4.1	10 (9 - 12)	-	33	-
	1 : 4	280	5.5	10	0	31	6

* on dry weight basis for 1,2 and 3 and wet weight basis for 4 and 5. Values are means with range shown in parentheses.

Table 22. Food intake, weight gain and calcium retention in rats fed 'dhokla' with and without lime powder treatment

	Diet		
	I Dhokla	II Dhokla lime treated*	III Dhokla with addition of calcium salt**
Calcium content of diet(mg/100g)	140	340	340
Food intake (g) per day	8.9	8.5	8.5
Weight gain (g) in four weeks	66±3.5	66±3.1	57±4.8
Hemoglobin content of blood (g%)	11.6±0.3	11.6±0.4	11.8±0.8
Balance studies for 6 days			
Calcium intake (mg)	75±2.9 (65-89)	168±5.3 (157-197)	179±4.4 (153-193)
Fecal calcium (mg)	21±1.7 (14-27)	62± 3 (46 - 75)	78±3.1 (62 - 91)
Urinary calcium (mg)	4±0.46 (2-5)	6±0.58 (3 - 8)	6±0.72 (2 - 9)
Amount of calcium retained (mg)	50±2.4 (42-63)	100±6.0 (74 -124)	95±5.7 (60 -113)
Calcium retained as percentage of weight gain	0.36±0.02 (0.30-0.49)	0.78±0.06 (0.57-1.1)	0.71±0.04 (0.45-0.83)

* 500 mg. of lime powder added to batter prepared from 100 g. of dry material.

** 750 mg. of a mixture of calcium carbonate, calcium phosphate and calcium citrate (46:19:11) added to 100 g. of dry food.

Values are means ± S.E.'s with range shown in parentheses.

Table 23. Composition of tibia and femur in rats fed dhokla with and without lime treatment

	Tibia			Femur		
	I Dhokla	II Dhokla lime treated	III Dhokla with calcium salts	I Dhokla	II Dhokla lime treated	III Dhokla with calcium salts
Length (cm)*	2.90 (2.8-3.0)	3.1 (3.0-3.3)	3.00 (2.9-3.3)	2.88 (2.8-2.95)	3.08 (3.05-3.15)	2.97 (2.9 -3.05)
Wet weight(mg)*	177 (124-234)	206 (140-276)	200 (150-266)	285 (269-292)	338 (323 - 363)	310 (287 - 328)
Dry weight(mg)*	120.7 (96 -124)	145.5 (127-178)	137.8 (90 -166)	149 (137-156)	185 (177-194)	175 (150 - 188)
Fat free dry* weight (mg)	110.7 (82 -125)	136.3 (117-167)	129.3 (103-157)	137 (126-143)	173 (158 - 188)	164 (150 - 176)
Ash (mg)*	56.7 (44 - 66)	66.6 (55 - 80)	64.1 (51 - 74)	59.7 (58 - 63)	89.2 (85 - 93)	79.0 (73 - 84)
Calcium (mg)*	18.1 (16.1-22.5)	26.5 (21.7-32.5)	24.3 (21.0-32.0)	22.1 (21.0-23.5)	34.4 (33 - 36)	30.4 (23.5-32.0)
Calcium (mg) per g of fat free dry weight	164.5 (145-196)	194.0 (165 - 225)	183.6 (166 - 209)	159 (150 - 170)	198 (191 - 212)	180 (170 - 190)

* Values are means per bone with range shown in parentheses.

Plate 1. Radiograph photo of right tibia of rats fed dhokla alone.

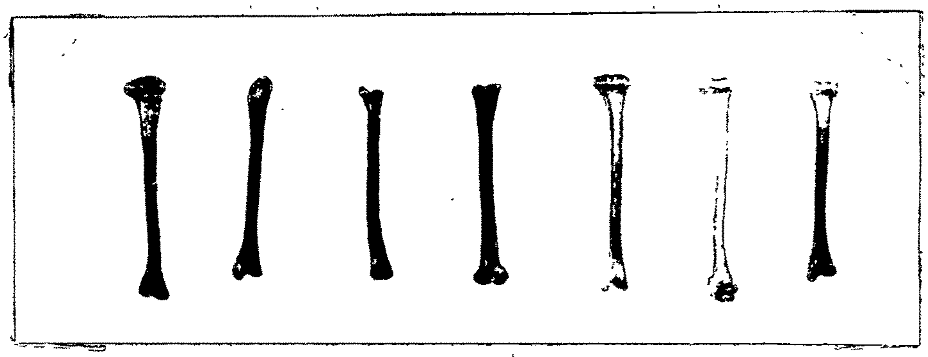


Plate 2. Radiograph photo of right tibia of rats fed dhokla lime treated.

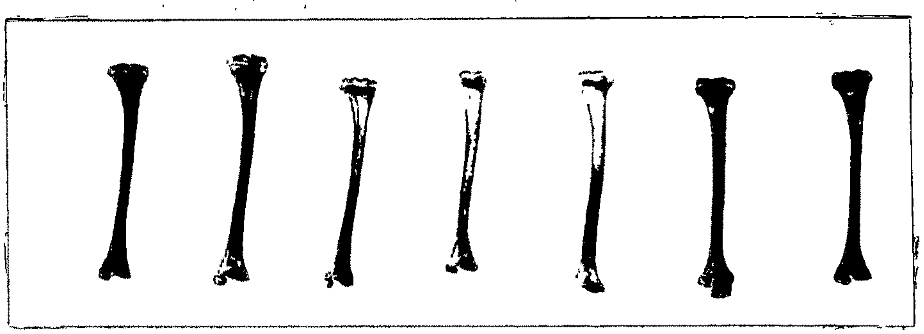
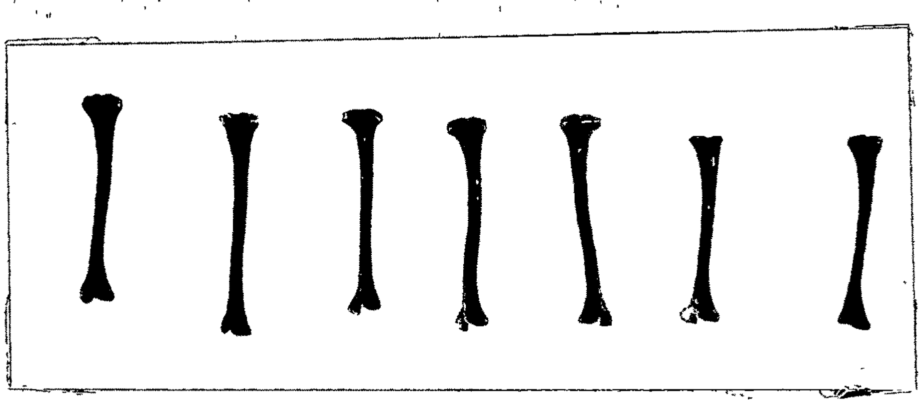


Plate 3. Radiograph photo of right tibia of rats fed dhokla with calcium salts.



The results of the sensory, chemical, and biological studies suggest that lime incorporation to acid foods is a simple and inexpensive way of increasing the calcium content of foods. Housewives can be easily educated to make such incorporation by adding about 1/4 tea spoon of lime powder for about two cups of batter or other acid foods using the maintenance of the acid taste as a criterion.

Regarding carotene, independent investigations in this laboratory have shown that carotene in leafy vegetables has fair availability (Table 24) (Rajalakshmi and Chari, 1968).

For the preparation of conjee from wheat and bengal gram, wheat was presoaked in water for a few hours and allowed to sprout for about twelve to twenty four hours, dried partially in the shade, roasted and ground. Bengal gram dal was steeped in water, dried similarly and roasted. This was done in order to improve acceptability, nutritive value and digestibility. Studies being carried out by another investigator (Kaushik, unpublished) show that sprouting of cereals and pulses increase their riboflavin and niacin contents. Similarly,studies being carried out suggest that roasting may not affect the nutritive value of the food mixture. In this connection heat treatment of legumes is found to result in an improvement in nutritive value (Aykroyd and Daughty, 1964). Previous studies in this laboratory showed that sprouted and roasted bajra (Pennisetum

Table 24. Vitamin A content of serum and liver in rats fed different leaf greens*

Leaf green used	Vitamin A value (i.u. per day per rat)**	Vitamin A in liver (i.u. per g of fresh weight)	Vitamin A in serum (µg per 100 ml)
Amaranth (Amarantus Gangeticus)	23	90 ± 5.2	21.3 ± 1.3
Colacasia (Colacasia esculenta)	23	96 ± 6.0	20.2 ± 2.6
Drumstick (Moringa ollifera)	26	153 ± 11.0	17.0 ± 1.4
Fenugreek (Trigonella foenum-graecum)	25	210 ± 7.0	21.1 ± 1.1
Spinach (Spinacera oleracea)	19	197 ± 15.2	24.7 ± 1.8
Standard vitamin A	38	280 ± 22.0	17.2 ± 2.9

Values are means ± S.E.'s.

* Rajalakshmi and Chari (1968).

**0.3 µg of vitamin A acetate and 0.6 µg of β-carotene taken as equal to 1 i.u.

typhoideum) have a greater nutritive value than raw bajra (Rajalakshmi R. and Ila Patel, unpublished).

Similarly, fermentation involved in the preparation of dhokla from wheat and bengal gram was found to result in an improvement in nutritive value (Table 25). Similar increases with fermentation have been reported by other investigators (Aykroyd and Doughty, 1964; Radhakrishna Rao, 1964). Previous studies in this laboratory had shown the beneficial effects of fermentation on growth and body composition of rats (Rajalakshmi and Vanaja, 1967).

As stated in the previous chapter, the diets fed at the baby centre and whole day diets consumed by experimental and control children were fed to rats. The results of this experiment (Expt. IV) are shown in Table 26. It can be seen from the same that the diet fed at the centre has a superior nutritive value as compared to the home diet in terms of the criteria employed. It is interesting to note that the improvement brought about by simple changes in the diet resulted not only in better growth and body composition but also in greater activities of brain enzymes and improved learning performance. These results are believed to be due to the improvement brought about in the nutritive value of the diet with regard to protein, vitamins and minerals. In this connection previous studies in this laboratory have shown the relation between the content and quality of protein

Table 25. Effect of fermentation on thiamine, riboflavin and niacin content of certain foods

	mg per 100 g. of dry ingredients		
	before fermentation	after fermentation	% increase
Thiamine in			
Dhokla*	0.36	0.42	16
Idli**	0.24	0.49	104
Khaman***	0.35	0.63	80
Riboflavin in			
Dhokla	0.31	0.42	35
Idli	0.26	0.49	88
Khaman	0.56	0.88	57
Niacin in			
Dhokla	1.11	2.40	110
Idli	1.18	2.31	95

* Ingredients are wheat and bengalgram dal (1:1)
** Ingredients are rice and blackgram dal (Phaseolus mungo) (4:1)
*** Ingredient is bengalgram dal.

Table 26. Biological data, cerebral enzymes, liver enzymes and psychological performance of rats fed home diet, home plus formulated diet and formulated diet.

	Home diet	Diet at centre + diet at home	Diet at the centre
Body composition			
Weight gain (g) in 8 weeks	70 ± 6.5	85 ± 4.8	90 ± 4.9
Blood hemoglobin (g/100 ml)	13.5 ± 0.14	13.5 ± 0.14	14.0 ± 0.12
Cerebral enzymes (Enzyme units/g wet weight)			
L-glutamate:NAD-oxidoreductase	61 ± 0.83	65 ± 0.71	66 ± 0.80
L-glutamate:1-carboxylase	16 ± 0.91	19 ± 0.82	23 ± 0.61
4-aminobutyrate: 2-oxoglutarate aminotransferase	22 ± 0.54	24 ± 0.63	26 ± 0.61
Liver enzymes			
Xanthine oxidase* (activity number)	6.2 ± 0.10	7.6 ± 0.13	7.6 ± 0.06
Succinate dehydrogenase**	18.5 ± 0.28	22.0 ± 0.42	29.5 ± 0.91
Psychological performance			
Error scores in the Hebb-Williams Maze	241 ± 9.2	184 ± 13.4	171 ± 11.7

Values are means ± S.E.'s

* Time required for reduction of methylene blue at 37°C under assay conditions.

** umoles of 2,3,4,Triphenyl tetrazolium chloride reduced per g of wet tissue per hour at 37°C under assay conditions.

in the diet on learning performance and brain enzymes (Rajalakshmi, Govindarajan and Ramakrishnan, 1965; Rajalakshmi, Pillai and Ramakrishnan, 1968). Preliminary studies suggest a similar relation with regard to vitamin A (Rajalakshmi and her associates, unpublished). It is not surprising that a global improvement of the diet results in similar changes. It is significant that this improvement is achieved with relatively minor changes in the diet accomplished without much increase in cost.

Field trials during 1965-66

Comparative data on the status of different groups at the start of the investigations are shown in Tables 27 to 33. It can be seen from the same that the experimentals and controls were matched with regard to the parameters measured. The upper class children on whom comparative data were collected during the second session were superior in physical, clinical and biochemical status and had better dietary intake. A question may be raised regarding the validity of the comparison made with the upper class children who were studied after the conclusion of the first session. Unpublished studies carried out in the department on upper class families show no change in dietary patterns between the years 1965-66 and 1966-67. We therefore feel justified in using the data for comparative purposes for the studies made in both years.

Table 27. Age, sex, height, weight and economic status of different groups at the start of the investigations

	Fed children (1965 Nov)	Controls (1965 Nov)	Upper class (1966 Nov)
Age (years)	3.6 (1.5 - 5.0)	3.8 (2.0 - 5.0)	3.8 (1.5 - 5.0)
Number of subjects			
boys	14	11	12
girls	11	9	8
T o t a l	25	20	20
Height (cm)*	87.9 ± 2.0 (65.7 - 104.8)	88.2 ± 2.6 (72 - 103)	90.7 ± 2.3 (73 - 108)
Weight (kg)*	10.4 ± 0.5 (5 - 14.5)	10.8 ± 0.44 (7 - 14)	12.8 ± 0.74 (8.6 - 17)
Income (rupees per month per family)	less than 100	less than 100	more than 300

* Values are means ± S.E.'s with range shown in parentheses.

Table 28. Composition of the diets consumed by different groups at the start of the investigations

Foodstuff	Approximate amount (g) consumed per day (a)		
	Fed children (1965 Nov)	Controls	Upper class (1966 Nov)
Cereals and millets (b)	125	140	75
Pulses (c)	15	15	15
Groundnut	- - - - - - - negligible - -		
Leafy vegetables	5	5	5
Other vegetables	30	30	50
Sugar or jaggery	20	20	40
Milk (buffalo)	60	50	550
Vegetable oils	10	10	10
Fruits	-	negligible	25
Eggs and flesh foods	nil	nil	5

(a) Values derived from records of food intake using the recipe method.

(b) Bajra, wheat, rice, and kodri, taken in the proportion of 4:2:1:1 in the case of controls and experimentals and wheat and rice taken in the proportion of 8:1 in the case of upper class.

(c) Mostly redgram.

Table 29. Nutrient content* of the diets consumed by different groups at the start of the investigations alongwith recommended values

Nutrient	Fed children (1965 Nov)	Controls (1965 Nov)	Upper class (1966 Nov)	Recommended allowance for children 1 - 6 years
Calories	700	720	1250	1150-1450 (FAO, 1957a)
Protein (g)	19	20	39	32 - 35 (FAO, 1957b)
Calcium (mg)	280	250	1200	400 - 500 (FAO, 1962)
Iron (mg)	17	19	13	20 - 30 (ICMR, 1958)
Vitamin A (I.U.)				
as carotene	590	590	~~1000~~ 500	2500-3000 (FAO, 1967) or
as preformed vitamin	100	80	~~1220~~ 1000	833 -1000
T o t a l	690	670	~~2220~~ 1500	
Thiamine (mg)	0.5	0.6	0.7	0.5 - 0.7 (FAO, 1967)
Riboflavin (mg)	0.4	0.4	0.9	0.6 - 0.9 (FAO, 1967)
Vitamin C (mg)	10.0	12.0	30.0	30 - 50 (ICMR, 1958)

* Calculated from values given for raw ingredients by Aykroyd, Gopalan and Balasubramanian (1966).

Table 30. Clinical status of children in the different groups at the start of the investigations

Clinical symptoms showing deficiency of (d)	No. and percentage having symptoms (c)		
	Fed children (n = 25) 1965 Nov.	Controls (n = 20) 1965 Nov.	Upper class (n = 20) 1966 Nov.
Calories			
(i) stunted physical growth (a)	9 (36)	7 (35)	0 (0)
(ii) adipose tissue deficient	6 (24)	5 (25)	0 (0)
Protein	10 (40)	8 (40)	0 (0)
Vitamin A	16 (64)	10 (50)	2 (10)
Riboflavin	5 (20)	4 (20)	0 (0)
Clinical assessment score (ICMR, 1948) (b)			
0	3 (12)	2 (10)	18 (90)
1 - 3	7 (28)	6 (30)	2 (10)
4 - 6	9 (36)	6 (30)	0 (0)
7 - 10	4 (16)	6 (30)	0 (0)
above 10	2 (8)	0 (0)	0 (0)

(a) Children having less than 75% of the average body weight of upper class children.

(b) Zero score indicates normal clinical status and the scores increase with deficiency symptoms.

(c) Percentages shown in parentheses.

(d) Criteria used for assessment of deficiency are shown in Table 30a.

Table 30a. Criteria used for assessment of clinical status

Deficient Nutrient	Item No. in the ICMR Schedule	Symptoms
Vitamin A	7	Conjunctiva slightly dry on exposure for ½ minute, lack of luster & Bitots' spots.
"	8	Slight discolouration of conjunctiva.
Riboflavin	17	Tongue pale but not coated
"	18	Tongue fissured
Vitamin C	20	Bleeding gums
Protein	8	Pigmentation of conjunctiva
"	23	Dry, brittle and lusterless hair.
"	24	Dry, rough and lusterless skin.
"	31	Oedema
"	35	Diarrhoea.
Calcium	32	Stigmata of past rickets.
Anaemia	-	Pale appearance.
--	20	Pyorrhoea

Table 31. Composition of blood and serum of subjects at the start of the investigations

(Amount per 100 ml) (a)

	Fed children (n = 25) 1965 Nov.	Controls (n = 20) 1965 Nov.	Upper class (n = 20) 1966 Nov.
Hemoglobin in blood (g)	9.3 ± 0.37 (6.2 – 12.0)	10.0 ± 0.4 (9.2 – 11.6)	11.4 ± 0.33 (9.8 – 13.4)
Amount in serum			
total protein (g)	6.0 ± 0.10 (5.4 – 6.6)	6.0 ± 0.14 (5.1 – 6.5)	6.9 ± 0.12 (6.2 – 7.4)
albumin (g)	3.1 ± 0.15 (2.3 – 4.2)	3.2 ± 0.24 (2.2 – 4.1)	3.9 ± 0.13 (3.3 – 4.6)
vitamin C (mg)	0.32 ± 0.05 (0.1 – 0.65)	0.36 ± 0.04 (0.28 – 0.54)	0.66 ± 0.11 (0.1 – 1.2)
carotene (μg)	47.0 ± 5.5 (13 – 64)	51.0 ± 7.2 (19 – 75)	66.0 ± 7.6 (17 – 110)
vitamin E (mg)	0.47 ± 0.06 (0.25 – 0.71)	0.55 ± 0.02 (0.37 – 0.66)	0.70 ± 0.25 (0.33 – 1.2)
alkaline phosphatase (b)	8.2 ± 0.52 (6.0 – 11.8)	6.4 ± 0.70 (2.9 – 8.1)	5.6 ± 0.3 (4.6 – 7.4)

(a) Values are means ± S.E.'s with range shown in parentheses.

(b) Millimoles of p-nitrophenyl phosphate split per hour per litre.

Table 32. Composition of urine of subjects at the start of investigation

	Amount excreted in urine during					
	4 hours			24 hours*		
	Fed children	Control	Upper class	Fed children	Control	Upper class
	1965 Nov.	1965 Nov.	1966 Nov.			
Urine volume	75 (54–133)	74 (52–130)	70 (40–110)	450 (324–798)	444 (312–780)	420 (240–660)
Creatinine (mg)	18 (11–35)	19 (16–38)	32 (15–45)	108 (66 –210)	114 (96 –228)	192 (90 –270)
Vitamin C (mg)	0.85 (0.3–3.0)	0.6 (0.2–2.0)	2.4 (1.0–6.0)	5.1 (1.8–18.0)	3.6 (1.2–12)	14 (6 – 36)
Thiamine (µg)	21.0 (10 –45)	21.5 (12– 43)	78 (44 –131)	126 (60 –270)	129 (72 –258)	468 (204–786)
Riboflavin (µg)	12.7 (5 –20)	12.2 (6 –25)	66 (40 –121)	76 (30 –120)	73 (36 –150)	396 (240–726)
Nitrogen (mg)	208 (112–535)	173 (148–518)	650 (490–760)	1248 (672–3210)	1038 (888–3108)	3900 (2940–4560)

* Values for 24 hours extrapolated from those for 4 hour urine.
Values are mean with range shown in parentheses.

Table 33. Composition of urine of subjects at the start of investigation (a)
(Expressed per gram of creatinine)

	Values per g of creatinine		
	Fed children (b) (n = 25) 1965 Nov.	Controls (n = 20) 1965 Nov.	Upper Class (n = 20) 1966 Nov.
Vitamin C (mg)	47.0 ± 5.0 (18 - 80)	31.0 ± 4.6 (11 - 68)	75.0 ± 9.5 (29 - 149)
Thiamine (μg)	1167 ± 113 (361 - 2444)	1139 ± 99 (531 - 1680)	2437 ± 234 (1430 - 4621)
Riboflavin (μg)	702 ± 59 (222 - 1428)	647 ± 25 (433 - 842)	2062 ± 172 (295 - 6108)
Nitrogen (g)	11.6 ± 1.6 (5.0 - 25.3)	9.0 ± 1.5 (7 - 22.5)	20.3 ± 1.2 (12.5 - 29.6)

(a) Values are means ± S.E.'s with range shown in parentheses.

(b) Urine samples were collected during the first two weeks of treatment.

The diets specified in Table 8 were given to the children for 154 days out of 180 days. But many of the children were not regular in attendance and the average attendance worked out to 56% (Table 34). This means that the children were fed on an average for only 48% of the total period. Consequently, the overall dietary intake of the fed children during the entire period under study was different from that on days when they took the meal at centre, as seen from Table 35, with the result that the dietary intake of the children was less than the amount intended for many of the foodstuffs. The resulting differences and the nutrient content of the diets consumed are shown in Table 36.

Inspite of the above limitations, there was considerable improvement in the physical status of the fed children as can be seen from Table 37. The increment obtained in weight compares favourably with that in the upper class studied. This is probably because the fed children had an accelerated growth with an appreciable improvement in the diet. Similar findings have been reported by many investigators (Subrahmanyan, Reddy, Moorjani, Sur, Doraiswamy, Sankaran, Bhatia and Swaminathan, 1954; Srikantia and Gopalan, 1961; Parpia, 1966b). It is a common finding that children previously undernourished and then rehabilitated show a greater rate of weight gain than children with a normal rate

Table 34. Attendance of the children fed at the play centre (1965 Nov. - 1966 April)

No. of children	25
Period of treatment	180 days
No. of days diet was provided	154 days
Average attendance at the centre as percentage of the days fed	56 %
No. of children with attendance above average and their mean attendance (a)	15 (70%)
No. of children with attendance below average and their mean attendance (a)	10 (36%)

(a) Shown in parentheses.

Table 35. Overall dietary intake of fed children, controls and upper class during the experimental period(a) (1965-66)

Foodstuffs	Average amount (g) consumed per day by fed children and controls during the period of treatment					Controls	Upper class children
	Fed children (Nov. '65 to April '66)					whole day Nov. '65 to April '66	whole day Nov. 1966
	at the centre	at home and the centre on feeding days	at home on non feeding days	Average whole day intake for the entire period for children with attendance			
				36%	70%		
Cereals and millets	60	110	125	120	115	140	75
Pulses	60	65	15	30	45	15	15
Groundnut	20	20	-	6	12	---- negligible ----	
Leafy vegetables	25	25	5	10	15	5	5
Other vegetables	20	30	30	23	25	30	50
Sugar or jaggery	17	37	20	25	30	20	40
Milk (buffalo)	-	50	60	50	50	50	550
Skim milk (b)	96	96	-	24	56	-	-
Vegetable oil	5	10	10	10	10	10	10
Fruits	30	30	-	10	20	negligible	25
Eggs & flesh foods	-	-	-	-	-	-	5

(a) Values are derived from records of food intake using recipe method.

(b) Prepared from 1/8th the weight of UNICEF skim-milk powder.

Table 36. Nutrient content of the diets consumed by fed children, controls and upper class during the experimental period (1965-66).

Nutrient	Nutrient intake per day per child(a)					Controls	Upper class children
	Fed children (Nov. '65 to April '66)						
	at the centre	at home and centre on feeding days	at home on non feeding days	Average for the entire period for children having attendance		whole day Nov. '65 to April '66	whole day Nov. 1966
				36%	70%		
Calories	740	1060	700	810	910	720	1250
Protein (g)	30	38	19	25	30	20	39
Calcium (mg)	350	480	280	310	400	250	1200
Iron (mg)	15	22	17	19	20	19	13
Vitamin A (I.U.)							
as carotene	2100	2300	590	1080	1600	590	~~1000~~ 500
as preformed vitamin	600	650	100	250	450	80	~~1220~~ 1000
total	2700	2950	690	1330	2050	670	~~2220~~ 1500
Thiamine (mg)	0.9	1.1	0.5	0.7	0.8	0.6	0.7
Riboflavin (mg)	0.9	1.0	0.4	0.6	0.7	0.4	0.9
Vitamin C (mg)	50	50	10	25	40	12	30

(a) Calculated from values given for raw ingredients by Aykroyd, Gopalan and Balasubramanian,(1966).

Table 37. Changes in height and weight of fed children, controls and upper class during experimental period. (1965-66)

	Fed children - (1965 Nov. - 1966 April)			Controls	Upper class
	36%* I (n = 10)	70%* II (n = 15)	I + II (n = 25)	1965 Nov. -1966 April (n = 20)	(1966 Nov. - 1967 April) (n = 20)
Weight (kg)	0.9 ± 0.11	1.7 ± 0.12	1.4 ± 0.11	0.5 ± 0.11	1.0 ± 0.14
Height (cm)	2.2 ± 0.18	3.1 ± 0.13	2.7 ± 0.11	2.0 ± 0.16	3.6 ± 0.35

Values are means ± S.E.'s

* Percentage of attendance.

of growth. Similar studies have been made in animal subjects in this laboratory (Rajalakshmi,R., Pillai,K.R., Thomas,N.T. and Mehta, A.R., unpublished). As may be expected children with less attendance showed a smaller weight gain than children with a greater attendance. The controls had poor weight gain. The data on height show a similar pattern, except for the fact that the increment in height of the fed children was less than that of the upper class children.

The change in the clinical status of the fed and control children during the period of treatment is shown in Table 38. It must be emphasized in this connection that the clinical examination was done byDr. K. Bagchi, Nutrition Adviser to the Government of India and he was not aware to which groups the subjects were assigned. In the fed group with a better attendance 53% were found to be free from clinical deficiency symptoms as against 6.6% initially. The percentage with high deficiency scores above 5 changed from 60% to 13%. A smaller degree of improvement is found in the fed children with less attendance. The improvement cannot be attributed to seasonal variations in food intake or factors such as infection or requirement, as no such improvement is found in the control group. Protein deficiency symptoms were found to clear in 9 out of the 10 children. Vitamin A deficiency symptoms were found to clear in 10 out of 16 children and riboflavin in all. The question may be raised as to how far

Table 38. Change in the clinical status of fed and control children during 1965 Nov. - 1966 April.

(No. and percentage (c) showing symptoms)

Clinical symptoms showing deficiency of : (d)	Fed children having attendance				Controls (n = 20)	
	(36% (n = 10)		70% (n = 15)			
	Initial	Final	Initial	Final	Initial	Final
Calories						
(i) stunted physical growth(a)	4(40)	2(20)	5(33)	1(66)	7(35)	8(40)
(ii) adipose tissue deficient	2(20)	0(0)	4(26)	0(0)	5(25)	5(25)
Protein	2(20)	1(10)	8(53)	0(0)	8(40)	6(30)
Vitamin A	6(60)	4(40)	10(66)	2(13.2)	10(50)	9(45)
Riboflavin	2(20)	0(0)	3(19)	0(0)	4(20)	3(15)
Clinical assessment(b) score (ICMR 1948)						
0	2(20)	4(40)	1(6.6)	8(53)	2(10)	2(10)
1 - 3	2(20)	2(20)	5(33)	5(33)	6(30)	7(35)
4 - 6	3(30)	3(30)	6(40)	1(6.6)	6(30)	8(40)
7 - 10	2(20)	1(10)	2(13)	1(6.6)	6(30)	3(15)
above 10	1(10)	0(0)	1(6.6)	0(0)	0(0)	0(0)

(a) Children having less than 75% of the average body weight of upper class children.

(b) Zero score indicates normal clinical status, and the scores increase with deficiency symptoms.

(c) Percentages are shown in parentheses.

(d) Criteria used indicated in Table 30a.

symptoms attributed to riboflavin deficiency are due to other factors. Although glossitis and corneal vascularisation may occur due to other deficiencies, riboflavin deficiency is a reasonable diagnosis when the diet is deficient in the vitamin. This view has also been expressed by Goldsmith (1964). A clinical deficiency of adipose tissue was not found in any of the fed children at the end of treatment. There was no significant change in the control group.

It is to be noted that the fed children with a better attendance compare with upper class children in clinical status with regard to protein, vitamin A and ribőflavin. The changes in the composition of blood and serum in the fed and control children are shown in Table 39. There is a significant improvement in the fed children as judged by all the parameters employed. No such improvement is evident in the control children. As may be expected, the improvement is greater in children with more regular attendance. The biochemical status of this group compared with that of upper class children as can be seen from Table 40 and there is no significant difference between the two groups with regard to any of the parameters measured except serum protein. It is encouraging to note this to be the case, inspite of differences in food intake between the fed children and upper class children shown previously in Table 36, and inspite of the previously poor

Table 39. Change in the composition of blood and serum in fed and control children during 1965 Nov. - 1966 April.

Constituent	Increment or decrement per 100 ml			Controls (n = 20)
	Fed children with attendance		I + II	
	36% (n = 10) I	70% (n = 15) II	(n = 25)	
Hemoglobin in blood (g)	0.3 ± 0.14	1.3 ± 0.42	0.9 ± 0.36	-0.2 ± 0.21
Serum				
protein (g)	0.16 ± 0.06	0.48 ± 0.11	0.32 ± 0.12	0.02 ± 0.02
albumin (g)	0.60 ± 0.15	0.90 ± 0.16	0.80 ± 0.16	0.12 ± 0.11
ascorbic acid (mg)	0.02 ± 0.03	0.23 ± 0.06	0.15 ± 0.04	0.01 ± 0.02
carotene (μg)	2.0 ± 2.0	29.0 ± 8.0	18.0 ± 5.0	-6.0 ± 4.0
vitamin E(mg)	0.02 ± 0.02	0.15 ± 0.03	0.10 ± 0.03	-0.14 ± 0.05
alkaline phosphatase (a)	-2.7 ± 1.0	-4.2 ± 0.7	-3.6 ± 0.55	-1.9 ± 0.6

(a) Millimoles of p-nitrophenyl phosphate split per hour/litre.

Values are means ± S.E.'s.

Table 40. Comparative data on the biochemical status of fed children with upper class (a)

	Fed children having attendance 70% (n = 15) 1965 Nov. to 1966 April.	Upper class (n = 20) 1966 Nov. to 1967 April
Increment in weight (kg)	1.7 ± 0.12	1.0 ± 0.4
Increment in height (cm)	3.1 ± 0.13	3.6 ± 0.35
	1966 April*	1966 Nov.**
Hemoglobin in blood (g%)	10.7 ± 0.40	11.4 ± 0.33
Serum (per 100 ml)		
protein (g)	6.5 ± 0.03	6.9 ± 0.12
albumin (g)	4.0 ± 0.09	3.9 ± 0.13
vitamin C (mg)	0.50 ± 0.08	0.66 ± 0.11
carotene (μg)	76 ± 5.2	66 ± 7.6
vitamin E (mg)	0.65 ± 0.04	0.70 ± 0.25
alkaline phosphatase (b)	4.9 ± 0.3	5.6 ± 0.3
Urine		
creatinine (mg/100 ml)	46 ± 5	46 ± 5
vitamin C (mg/g creatinine)	144 ± 24	75 ± 9.5
thiamine (μg/g creatinine)	2179 ± 250	2437 ± 234
riboflavin (μg/g creatinine)	1535 ± 212	2062 ± 172
nitrogen (g/g creatinine)	15.6 ± 1.5	20.3 ± 1.2

(a) Values are means ± S.E.'s
(b) Millimoles of p-nitrophenylphosphate split per litre per hour.

* Investigated in 1966 April.
** Investigated in 1966 Nov.

nutritional status of the fed children. We can therefore conclude that the diets formulated are reasonably adequate for children in this age group. The difference in serum protein may be due to the difference in average protein intake between the two groups. This difference would not have existed, if the diet formulated have been available to the child on all days as can be seen from Table 36.

The changes in the composition of urine are presented in Table 41. The same pattern of differences between the fed and control children is found, differences varying with attendance at the feeding centre. The significant increase in the excretion of creatinine (Tables 41 and 42) show an increased rate of endogenous protein metabolism. It is well known that the same is decreased in conditions of under-nourishment. (Arroyave, 1962). The urinary excretion of vitamins is found to increase in the fed children both in absolute terms and as expressed per g. of creatinine. The latter is evident inspite of the increase in creatinine excretion itself. The values compare with those of upper class children (Table 42) except perhaps in the case of g nitrogen/g creatinine (Table 40).

A question may be raised regarding the validity of extrapolating for 24 hours from values derived for 4 hours. The rate of excretion of many urinary constituents is believed to be more or less uniform during the day (Arroyave, 1962). However the validity of this approach was investigated

Table 41. Change in the composition of urine in fed and control children during 1965 Nov. - 1966 April.

Constituent	Increment or decrement in urine value (a) for Fed children having attendance			Controls (n = 20)
	36% (n = 10)	70% (n = 15)	Total with attendance 56% (n=25)	
Creatinine mg/100 ml	9.0 ± 4.7	24.0 ± 4.3	18.0 ± 3.4	5.0 ± 2.1
<u>Values per g of creatinine</u>				
Vitamin C (mg)	45 ± 31	113 ± 22	86 ± 18	16 ± 6
Thiamine (μg)	458 ± 284	1333 ± 270	986 ± 193	41 ± 22
Riboflavin (μg)	778 ± 290	855 ± 210	824 ± 165	- 1 ± 37
Nitrogen (g)	2.8 ± 1.2	4.0 ± 1.3	3.5 ± 1.1	0.6 ± 0.4

(a) Values are means ± S.E.'s.

Table 42. Extrapolated values for excretion of selected urinary constituents of fed control and upper class children

	Amount excreted in urine during					
	4 hours*			24 hours*		
	Fed children having 70% attendance (n = 15)	Controls (n = 20)	Upper class (n = 20)	Fed children having 70% attendance	Controls	Upper class
	1966 April	1966 April	1966 Nov.	1966 April	1966 April	1966 Nov.
Volume (ml)	60 (34-100)	66 (35-110)	70 (40-110)	360 (204-600)	396 (210-660)	420 (240-660)
Creatinine (mg)	28 (10-38)	21 (13-35)	32 (15-45)	168 (60-228)	126 (78-210)	192 (90-270)
Vitamin C (mg)	4.0 (0.7-10)	1.0 (0.5-2.0)	2.3 (1.0-6.0)	24 (4 - 60)	6.0 (3 - 12)	14 (6 - 36)
Thiamine (μg)	61 (14-128)	25 (16-37)	78 (44-131)	366 (84-768)	150 (96-222)	468 (204-786)
Riboflavin (μg)	43 (14-122)	17 (10-30)	66 (40-121)	258 (84-732)	102 (60-180)	396 (240-726)
Nitrogen (mg)	438 (143-783)	220 (167-533)	650 (490-760)	2628 (858-4698)	1320 (1002-3198)	3900 (2940-4560)

* Values for 24 hour extrapolated from these for 4 hour urine.
Values are mean with range shown in parentheses.

in a selected subject and the data are presented (Table 43). The extrapolated values are found to be in close agreement with actual values.

The biochemical status of the different groups studied is considered in terms of standards laid down in the ICNND laboratory manual for nutrition surveys (1963). Except in the case of hemoglobin, less than 10% of the fed children are found to have deficient values and a high proportion are found to have acceptable values (Table 44). The urine values with regard to riboflavin were not found to be seriously deficient even in the control children although many of them are found to have clinical deficiency symptoms. Similar observations have been made in independent investigations in this laboratory on school children and adult women including pregnant and lactating. These studies raise questions regarding the validity of the norms suggested by the ICNND (1963) for riboflavin excretion in urine. However, the extrapolated values derived for the amounts excreted are consistent with data on dietary intake.

In using the amount of riboflavin per g. of creatinine as an index of riboflavin status it is assumed that riboflavin excretion will be proportional to creatinine excretion. Children excrete less creatinine than adults and the volume of urine is also less, so that the values may become

Table 43. Comparative data on the urinary excretion of different constituents during 4 hour and 24 hour in a selected subject (a)

	amount excreted in						extrapolated value derived from 4 hour urine for 24 hours	
	4 hours		20 hours		24 hours			
	day 1	day 2	day 1	day 2	day 1	day 2	day 1	day 2
Urine volume (ml)	72	86	380	410	452	496	432	516
Creatinine (mg)	25.5	24.0	114.5	113.0	140	137	153	144
Vitamin C (mg)	0.6	0.7	2.7	4.2	3.3	4.9	3.6	4.2
Thiamine (ug)	58	66	273	318	331	384	348	396
Riboflavin (ug)	124	131	609	625	733	756	744	786
Nitrogen (mg)	531	664	2599	2852	3130	3516	3186	3984

(a) 4 hour and 20 hour samples were collected separately for two consecutive days and known volumes of the same analysed. The subject was aged 3.8 years and belonged to the upper class.

Table 44. Biochemical status at the end of treatment on the basis of ICNND (a) (1963) standards

Constituents	Percentage of children in the deficient, low and acceptable groups in											
	Fed children (1966 April)						Controls (1966 April)			Upper class (1966 Nov)		
	36%* (n = 10)			70%* (n = 15)			(n = 20)			(n = 20)		
	D	L	A	D	L	A	D	L	A	D	L	A
Blood and serum												
hemoglobin	30	30	40	19.8	19.8	60.4	66.6	16.6	16.6	15	25	60
total protein	10	40	50	6.6	39.6	54.8	50.0	33.3	16.6	0	15	85
albumin	10	20	70	6.6	13.2	80.2	25.0	50.0	25.0	0	10	90
vitamin C	0	10	90	0	0	100	8.3	41.6	50.0	0	10	90
carotene	10	20	70	0	6.6	93.4	33.3	25.0	41.7	10	10	80
Urine												
thiamine	0	0	100	0	0	100	0	0	100	0	0	100
riboflavin	0	10	90	0	6.6	93.4	0	10	90	0	0	100

(a) ICNND laboratory manual for nutrition surveys (1963).
D = deficient, L = Low, A = Acceptable.
* Attendance percentage.

exaggerated when expressed in terms of amount per g. of creatinine. It would therefore seem more reasonable to consider 24 hour excretion as we should expect that a significant proportion of vitamin consumed would spill over in the urine and that this amount would vary with the nutriture of the subject with regard to this vitamin.

An output of more than 200 µg in 24 hours is considered satisfactory. (Horwitt, Harvey, Hills, Liebert, 1959). Further it would seem reasonable to extrapolate from 4 hour values for 24 hour excretion, as excretion in 4 hour has been found to be proportional to that in 24 hour (Horwitt, Harvey, Hills, Liebert, 1950). As stated earlier, this has been confirmed in a selected subject studied in this laboratory.

<u>Field trials during 1966-67</u>

Data on the results of investigations carried out in 1966-67 are presented in Table 45. The different groups are found to be reasonably matched with regard to height and weight at the beginning of the study. The clinical status of the subjects at the start of the investigations are shown in Table 46. The initial status of the fed and control children are somewhat better than that of the previous year because both groups included some children belonging to the experimental group in the previous year.

The attendance this year was found to be much higher than in the previous year (Table 47). This was because of better

Table 45. Age, sex, height, weight and economic status of different groups at the start of the investigation in 1966

	Fed children(a)	Controls(b)	Upper class(c)
	1966 Oct.		(1966 Nov.)
Age (years)	4.5 (2.5–6.5)	4.4 (2.5–6.5)	3.8 (1.5–5.0)
No.of subjects			
boys	19	8	12
girls	14	6	8
total	33	14	20
Height (cm)*	93.9±2.5 (74.0–106.8)	94.4±1.9 (83.0–105.9)	90.7±2.3 (73.0–108.0)
Weight (kg)*	12.2±0.51 (8.0 –16.5)	12.1±0.56 (8.0 –16.5)	12.8±0.74 (8.6 –17.0)
Income (rupees per month per family)	less than 100	less than 100	more than 300

(a) Includes 12 subjects from the fed group and seven subjects from the control group of previous year.

(b) Includes 5 subjects from the fed group and four subjects from the control group of the previous year.

(c) The subjects in this were same as shown in previous tables.

* Values are means with S.E.'s and range shown in parentheses.

Table 46. Clinical status of children in different groups at the start of investigations in 1966.

Clinical symptoms showing deficiency of :	No. and percentage (c) showing symptoms		
	Fed children (n = 33)	Controls (n = 14)	Upper class (n = 20)
	-1966 Oct.-		-1966 Nov.-
Calories			
(i) stunted physical growth(a)	10 (30)	4 (28)	0 (0)
(ii) adipose tissue deficient	8 (24)	3 (21)	0 (0)
Protein	10 (30)	5 (35)	0 (0)
Vitamin A	11 (33)	6 (42)	2 (10)
Riboflavin	2 (6)	2 (14)	0 (0)
Clinical assessment Score (ICMR,1948)(b)			
0	7 (21)	1 (7)	18 (90)
1 - 3	9 (27)	4 (28)	2 (10)
4 - 6	12 (36)	6 (42)	0 (0)
7 - 10	5 (15)	3 (21)	0 (0)

(a) Children having less than 75% of the average body weight of upper class children.

(b) Zero score indicates normal clinical status and the score increases with deficiency symptoms.

(c) Percentage values are shown in parentheses.

Table 47. Attendance of the children fed at the play centre

(1966 October to 1967 February)

No. of children	33
Period of treatment	150 days
No. of days diet was provided	122
Average attendance at the centre as percentage of days fed.	80 %
No. of children with attendance above average and their mean attendance(a)	20 (95%)
No. of children with attendance below average and their mean attendance(a)	13 (60%)

(a) Shown in parentheses.

cooperation from the parents after they were assured that no blood samples would be collected. Incidentally, in the previous year, many of the parents believed that the collections (0.3 - 0.5 ml of blood) was for blood banks and complained that what was being given at one hand was being taken away at the other.

The dietary intake of the different groups is shown in Table 48. The diets fed at the centre differed from the one fed in the preceding year in the following respects. Fruits were omitted, and skim milk powder was reduced from 12 to 2 g. Lime powder was incorporated in the fermented foods prepared (Dhokla). The reduction in skim milk and omission of fruit were done in order to make the diets fed at the centre closer to that at home and to reduce the increase in cost without seriously decreasing the nutritive value. The resulting decrease in calcium content was sought to be compensated by incorporating lime powder in dhokla.

The nutrient content of the diets consumed by the different groups is shown in Table 49. A somewhat greater calorie consumption was found in the fed and control children as compared to the previous year probably because of difference in age by about 0.6 years and 0.9 years in the case of controls and experimentals. Apart from a decrease in vitamin C content due to the omission of fruit, and preformed vitamin A due to the reduction in skim milk powder

Table 48. Dietary intake of fed children, controls and upper class during the experimental period(a)

Foodstuff	Average amount (g) consumed per day by fed children and controls during the period of treatment: Fed children (Oct.'66 to Feb.'67) at the centre	at home and centre on feeding days	Average whole day intake for the entire period for children with attendance 60%	95%	Controls whole day Oct.'66 to Feb.67	Upper class children whole day Nov.1966
Cereals and millets	60	110	126	117	140	75
Pulses	60	70	46	59	25	15
Groundnut	20	20	10	15	negligible	negligible
Leafy vegetables	25	25	17	21	10	5
Other vegetables	20	40	40	40	40	50
Sugar or jaggery	10	30	25	27	20	40
Whole milk (buffalo)	-	50	50	50	50	550
Skim milk as dilute buttermilk(b)	90	90	30	60	-	-
Vegetable oils	5	10	10	10	10	10
Fruits	negligible	negligible	negligible	negligible	negligible	25
Eggs and flesh foods	- do -	- do -	- do -	- do -	- do -	5

(a) Values are derived from records of food intake by recipe method.

(b) Prepared from 1/30 of UNICEF skim milk powder.

Table 49. Nutrient content of the diets consumed by fed children, controls and upper class during the experimental period. (1966-67)

Nutrient	Nutrient intake per day per child(a)				Controls	Upper class
	Fed children (Oct.'66 to Feb.'67)				whole day Oct.'66 to Feb.67	children whole day Nov.,1966
	at the centre	at home and centre on feeding days	Average for the entire period for children having attendance			
			60%	95%		
Calories	650	1060	930	1000	820	1250
Protein (g)	27	37	30	33	22	39
Calcium (mg)	420(b)	500(b)	350(b)	420(b)	250	1200
Iron (mg)	14	20	20	20	20	13
Vitamin A (I.U.)						
as carotene	1800	1900	1375	1660	890	1000
as preformed vitamin	180	250	160	210	80	1220
total	1980	2150	1535	1870	970	2220
Thiamine (mg)	0.7	0.9	0.7	0.8	0.6	0.7
Riboflavin (mg)	0.6	0.7	0.6	0.6	0.5	0.9
Vitamin C (mg)	18	22	18	20	14	30

(a) Calculated from values given for raw ingredients by Aykroyd, Gopalan and Balasubramanian (1966).

(b) Inclusive of calcium incorporated as lime.

(which was enriched with vitamin A) there were no serious differences in the nutritive value of the diets of the fed children.

The change in heights and weights of the fed children as compared to that of controls is shown in Table 50. The fed children are found to show greater increases in weight, the children with a higher attendance rate showing a greater weight gain than the upper class children. Although the fed children showed a greater increment in height than the controls, this was less than that in the upper class subjects. Both these observations are consistent with those in the previous year. The weight increments in the two years were also comparable.

The clinical status of the different groups at the beginning and at the end of study is shown in Table 51. There were no great differences between the clinical status of the subjects at the start of the first and second sessions except with regard to the percentage of subjects having vitamin A deficiency symptoms and of those free from deficiency symptoms although the subjects in the latter included some who were in the experimental group in the previous year. This might have been because of some deterioration during the period 1966 April to 1966 October, when the feeding programme was not in operation. As in the previous year the fed children are found to show a significant improvement in clinical status.

Table 50. Changes in height and weight of fed children, controls and upper class during experimental period

	Fed children – 1966 Oct. – 1967 Feb.			Controls	Upper class
				1966 Oct. –1967 Feb.	(1966 Nov. – 1967 April)
	60%** I (n = 13)	90%** II (n = 20)	I + II (n = 33)	(n = 14)	(n = 20)
Weight (kg)	1.0 ± 0.08	1.8 ± 0.11	1.5 ± 0.10	0.5 ± 0.18	1.0 ± 0.14
Height (cm)	3.0 ± 0.16	3.2 ± 0.14	3.1 ± 0.12	2.4 ± 0.12	3.6 ± 0.35

* Values are means ± S.E.'s

** Attendance percentage.

Table 51. Change in clinical status of fed and control children during 1966 Oct. to 1967 Feb.

Clinical symptoms showing deficiency of :	No. and percentage(c) showing symptoms					
	Fed children having attendance				Controls	
	(60% (n = 13)		95% (n = 20)		(n = 14)	
	Initial	Final	Initial	Final	Initial	Final
Calories						
(i) stunted physical growth(a)	3(23)	1(8)	7(35)	1(5)	4(28)	3(21)
(ii) adipose tissue deficient	2(15)	0(0)	6(30)	0(0)	3(21)	3(21)
Protein	3(23)	1(7.7)	7(35)	1(5)	5(35)	4(28)
Vitamin A	4(31)	2(15)	7(35)	2(10)	6(42)	5(35)
Riboflavin	1(7.7)	0(0)	1(5)	0(0)	2(14)	1(7)
Clinical assessment score (b)						
0	1(8)	4(31)	6(30)	15(75)	1(7)	1(7)
1 - 3	5(38)	6(46)	4(20)	3(15)	4(28)	5(35)
4 - 6	5(38)	2(15)	7(35)	2(10)	6(42)	5(35)
7 - 10	2(15)	1(81)	3(15)	0(0)	3(21)	3(21)

(a) Children having less than 75% of the average body weight of upper class children.

(b) Zero score indicate normal clinical status and the score increase with deficiency symptoms.

(c) Percentages are shown in parentheses.

Here again, the clinical examination was done by Dr. K.Bagchi, Nutrition Adviser to the Government of India, who was unaware of the treatment given to the subjects. The improvement is found to be of the same order with a greater percentage in the second year free from deficiency symptoms. The clinical status of the fed children with a higher rate of attendance compares reasonably with that of the upper class children at the end of the session.

The data on urinary excretion of fed and control children are given in Tables 52 and 53. The pattern of differences is similar to that found in the previous year (Table 54). The differences in the increment in the excretion of some of the constituents in the two experiments is believed to be possibly due to the difference in age of the subjects, differences in the period of treatment, and some differences in protein and riboflavin content of the diet. (The diet provided at the centre in the first year contained an extra 80 g. of skim milk powder).

The results of radiological examination are shown in Table 55. The fed children are found to have a superior bone status in terms of the parameters employed. However, they are inferior to the upper class children. This may be because the upper class children were receiving diets adequate in calcium content from birth onwards whereas the fed children had a previously poor intake and retarded bone development on the basis of the data obtained in controls.

Table 52. Change in the composition of urine of fed and control children during 1966 October to 1967 February.

	Amount excreted in urine during 24 hours*					
	Fed children having attendance				Controls	
	60 % (n = 10)		95 % (n = 20)		(n = 8)	
	Initial	Final	Initial	Final	Initial	Final
Urine volume (ml)	530 (300-660)	520 (240-660)	550 (300-900)	534 (324-798)	555 (300-900)	522 (318-722)
Creatinine (mg)	138 (90-240)	162 (132-246)	126 (72-246)	180 (102-252)	135 (63-187)	141 (84-192)
Vitamin C (mg)	6.0 (1.8-10.8)	18.0 (6.6-39.6)	6.6 (1.2-16.2)	25.8 (2.4- 48)	5.3 (1.3-16.8)	9.6 (1.8-23.4)
Thiamine (μg)	156 (78-222)	216 (120-378)	150 (36-228)	318 (180-438)	132 (58-230)	152 (83-203)
Riboflavin (μg)	144 (48-288)	186 (78-420)	120 (36-252)	222 (84-426)	130 (49-282)	135 (54-216)
Nitrogen (mg)	1680 (792-2920)	2220 (1200-3186)	1842 (420-4500)	3006 (1440-4980)	1598 (845-2974)	1758 (920-2430)

* Values for 24 hours extrapolated from these for 4 hour urine.

Values are mean with range shown in parentheses.

Table 53. Changes in the composition of urine in fed and control children during 1966 October to 1967 Feb. (Expressed per g creatinine)

Constituents	Fed children having attendance 60% (n = 10)			Fed children having attendance 95% (n = 20)			Controls (n = 8)		
	Initial	Final	Difference	Initial	Final	Difference	Initial	Final	Difference
Creatinine mg/100 ml	26 ±2.9	31 ±2.9	5 ±1.4	23 ±2.7	34 ±2.2	11 ±1.4	24 ±3.6	27 ±2.3	3 ±1.5
<u>Values per g of creatinine</u>									
Vitamin C (mg)	44 ±8	111 ±13	68 ±3	52 ±8	143 ±21	91 ±10	39 ±12	68 ±11	29 ±9
Thiamine (μg)	1130 ± 98	1333 ±121	203 ±27	1190 ± 82	1766 ± 93	570 ±77	977 ±105	1078 ±116	101 ±15
Riboflavin (μg)	1043 ±132	1148 ±162	105 ±80	952 ±68	1233 ± 95	281 ±84	962 ±106	957 ±109	-5 ±17
Nitrogen (g)	12.2 ±1.3	13.6 ±0.9	1.4 ±0.3	14.6 ±0.9	16.7 ±1.2	2.1 ±0.4	11.8 ±1.1	12.5 ±1.3	0.7 ±0.4

Values are means ± S.E.'s.

Table 54. Comparative data on the excretion of selected urinary constituents in fed and control children in 1965-66 and 1966-67

	Amount excreted in urine in 24 hour							
	Fed children having attendance				Controls			
	70 % (n = 15) (1965 - 66)		95 % (n = 20) (1966 - 67)		(n = 20) (1965 - 66)		(n = 8) (1966 - 67)	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final
Creatinine (mg)	106 (66-198)	168 (60-228)	126 (72-246)	180 (102-252)	114 (96-228)	126 (78-210)	135 (63-187)	141 (84-192)
Vitamin C (mg)	3.2 (1.8-15)	24.0 (4 - 60)	6.6 (1.2-16.2)	25.8 (2.4-48)	3.6 (1.2-12)	6.0 (3 - 12)	5.3 (1.3-16.8)	9.6 (1.8-23.4)
Thiamine (µg)	111 (60-210)	366 (84-768)	150 (36-228)	318 (180-438)	129 (72-258)	150 (96-222)	132 (58-230)	152 (83-203)
Riboflavin (µg)	72 (32-120)	258 (84-732)	120 (36-252)	222 (84-426)	73 (36-150)	102 (60-180)	130 (49-282)	135 (54-216)
Nitrogen (mg)	1228 (672 -2810)	2628 (858 -4698)	1842 (420 - 4500)	3006 (1440 -4980)	1038 (888 - 3108)	1320 (1002 - 3198)	1598 (845 - 2974)	1758 (918 - 2430)

Values for 24 hours extrapolated from those for 4 hour urine.

Values are mean with range shown in parentheses.

Table 55. Results of the radiological examination of the right wrist and palm of fed, control and upper class children.

	Fed children having 95% attendance	Control	Upper class
	---------- 1967 Feb.	-----	--Jan. 1968---
Number of subjects			
boys	11	7	4
girls	6	4	2
total	17	11	6
Chronological age (years)	4.9 (3-6.5)	5.0 (3-6.5)	4.4 (3 - 6)
Bone age (years)	4.7 (2 - 7)	3.3 (2 - 7)	4.7 (3.8-6.0)
Bone age x 100 / chronological age	96±2.4 (66-110)	66±5.3 (50-100)	106±6.5 (95-125)
Number with normal ossification centres	9 (53%)	2 (18%)	6 (100%)
Average No. of ossification centres	4.8 (2 - 7)	3.2 (2 - 7)	4.7 (4 - 6)
No. with normal calcification status(a)	10 (60%)	2 (18%)	6 (100%)

(a) Significance

$P < 0.1$

$t = 1.8$

It has been found that the response obtained with dietary rehabilitation with regard to calcium may be slow and may take as long as two years (Garn, 1966). It is encouraging that the fed children have shown a significant improvement. Typical radiographs of a selected subject from each group are shown in plates 4, 5 and 6.

The data on salivary amylase are given in Table 56. It is interesting to note from the same that the activity of this enzyme is greater in the fed children. As mentioned earlier, serum amylase is found to be lowered in protein deficiency (Brock and Hansen, 1962). The results on salivary amylase are consistent with this finding and suggest the feasibility of using this simple procedure as a measure for the assessment of nutritional status.

Table 56

Salivary amylase activity of fed and control children

	Fed children n = 13	Controls n = 10
Salivary amylase mg of maltose liberated/3 minutes/ml of saliva.	326 ± 11.14 (285 - 389)	280 ± 9.0 (225 - 315)

The data on psychological performance obtained by a coinvestigator are shown in Table 57. A significant increase in the I.Q. scores of the 'fed' children is evident whereas no such increase is found in the controls.However,

Radiograph photo of right wrist and palm of a selected subject from each group.
(Subjects matched for age and sex. The radiographs are typical of the group).

Plate 4. Fed child

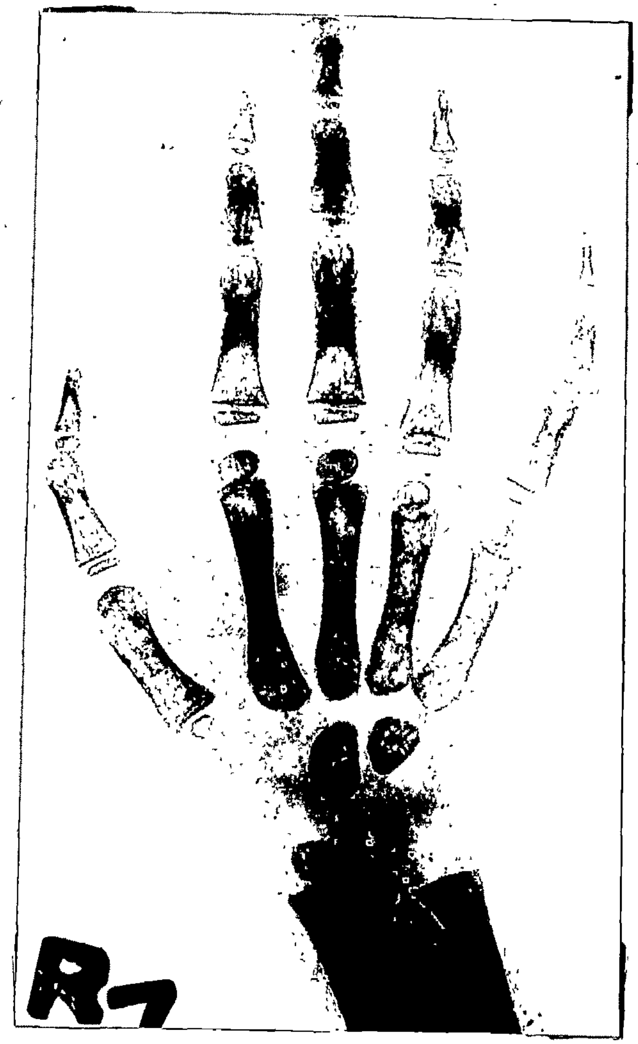


Plate 5. Control child

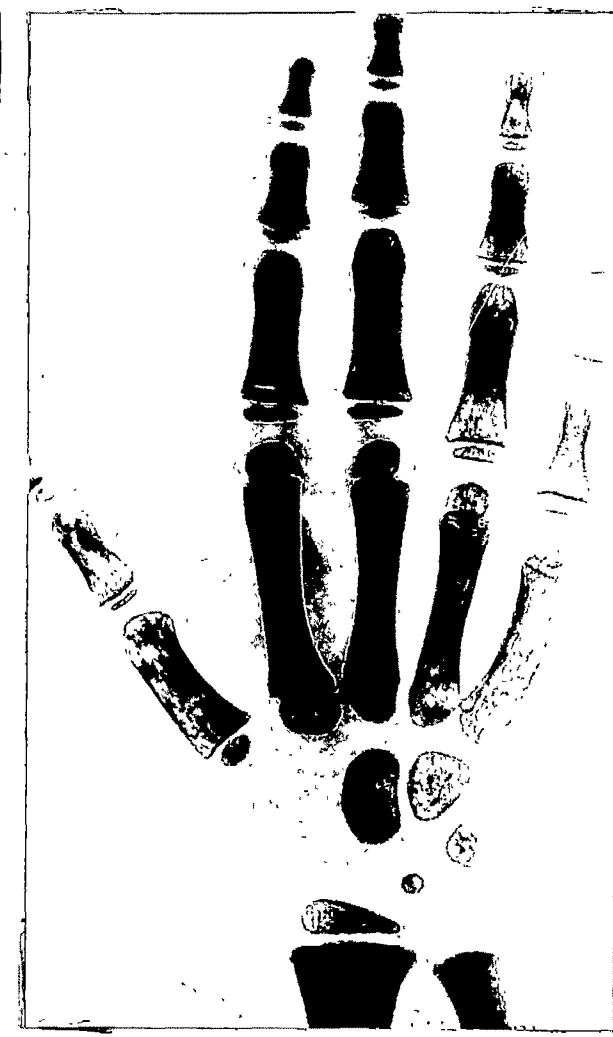


Plate 6. Upper class child

Table 57. Psychological performance of fed, control and upper class children

	Fed children (n = 33)			Controls (n = 14)			Upper class
	Initial 1966 Oct.	Final 1967 Feb.	Difference	Initial 1966 Oct.	Final 1967 Feb.	Difference	(n = 14) 1967 March
Children above 5 years of age, I.Q. score on WISC (Wechsler, 1949).							
Verbal	82.0±3.5 (61 - 95)	88.0±3.4 (71-101)		86.0±3.2 (74 - 91)	86.0±3.4 (75- 90)		101
Performance	82.0±2.8 (62 - 97)	88.0±3.7 (45 -107)		89.0±3.7 (75 - 96)	90.0±4.2 (75- 96)		97
total	80.0±3.9 (58 - 96)	88.0±3.4 (70- 104)	7.2±0.09	86.0±3.8 (72 - 93)	86.0±3.8 (75- 90)	0.8±0.09	-

Values are means ± S.E.'s with range shown in parentheses.

the two groups differed not only in nutritional status but also in environmental stimulation and it is hard to conclude that the increase was brought about by nutritional improvement.

It will be recalled that some of the subjects used in the second session also participated in the first session. Table 58 gives comparative data on increments in weight found in different groups during different phases of the investigations. It is interesting to note that the increments were greater when the children were fed, and decreased, when if either the programme was not in operation or the children switched to the control group. A similar picture is found when the increment in weight is considered in relation to increment in height (Table 59). Similar data on urine values presented in Table 60 give essentially the same picture, but the increments obtained in the second year seem to be less presumably because of differences in the age of the children, period of treatment and amounts consumed of protein and riboflavin.

The present studies demonstrate that pre-school children fed on mainly vegetable sources of foods can achieve an adequate nutritional status, if the vegetable foods are suitably combined and processed.

Table 58. Increment in weight of fed and control children during periods of feeding and non-feeding

Group affiliation during period 1965/66 I	1966/67 III	Nov. '65 to April, '66 I	May, '66 to Sept. '66 II*	Oct. '66 to Feb. '67 III
		Mean increment in weight (kg)		
Exptl. (n = 12)	Exptl.	1.63 (0.5-3.5)	0.23 (-1.0-1.0)	1.14 (0.0-2.0)
Exptl. (n = 5)	Control	1.03 (0.5-2.0)	0.30 (-0.5-1.0)	0.5 (0.0-1.0)
Control (n = 7)	Exptl.	0.45 (0.0-2.0)	0.46 (-0.5-1.0)	1.25 (0.5-2.5)
Control (n = 4)	Control	0.55 (0.0-2.0)	0.30 (-0.5-1.0)	0.30 (0.0-0.5)

Table 59. Ratio of increment in weight (kg) to increment in height (cm) of fed and control children during periods of feeding and non-feeding

Exptl. (n = 12)	Exptl.	0.54 (0.0-0.77)	0.065 (-0.06-0.21)	0.42 (0.0-0.74)
Exptl. (n = 5)	Control	0.48 (0.0-0.62)	0.09 (-0.18-0.29)	0.21 (0.0-0.45)
Control (n = 7)	Exptl.	0.23 (0.0-0.87)	0.22 (-0.33-0.26)	0.41 (0.0-0.79)
Control (n = 4)	Control	0.27 (0.0-0.62)	0.13 (-0.27-0.42)	0.20 (0.0-0.39)

*Feeding programme not in operation during period II.

Values are mean with range shown in parentheses.

Table 50. Change in the urinary excretion of fed and control children during period of feeding and non-feeding

(a) Mean change in creatinine (mg/100 ml)

Group affiliation during period 1965/66 I	1966/67 III	Nov.'65 to April,'66 I	May '66 to Sept.'66* II	Oct.'66 to Feb.'67 III
Exptl. (n = 11)	Exptl.	+29 (7-40)	-21 (-56-11)	+14 (-18-48)
Exptl. (n = 3)	Control	+13.5 (9-19)	+2 (-8 -12)	+1 (-1 -2)
Control (n = 5)	Exptl.	+5 (-1-15)	-6 (-25- 2)	+15 (4 -35)

(b) Mean change in vitamin C (mg/g creatinine)

Exptl. (n = 11)	Exptl.	+118 (-10-322)	-102 (-271- -17)	+74 (-37- 292)
Exptl. (n = 3)	Control	+126 (30 -223)	-109 (-187- -31)	+13 (-7 - 34)
Control (n = 5)	Exptl.	+28 (13 - 48)	+4 (-35 - 40)	+46 (14- 115)

(c) Mean change in thiamine (µg/g creatinine)

Exptl. (n = 11)	Exptl.	+1047 (-117-2431)	-1006 (-3503-700)	+185 (-10-635)
Exptl. (n = 3)	Control	+935 (275 -1716)	-1093 (-2416-270)	+30 (-165-107)
Control (n = 5)	Exptl.	-199 (-866-195)	-436 (-856- -135)	+579 (171-1269)

*Feeding programme not in operation during period II.

Values are mean with range shown in parentheses.

(d) Mean change in riboflavin (μg/g creatinine)

Group affiliation during period 1965/66 I	1966/67 III	Nov.'65 to April '66 I	May '66 to Sept.'66* II	Oct.'66 to Feb. '67 III
Exptl. (n = 11)	Exptl.	+646 (-93-1618)	-625 (-2310-107)	+387 (-181-1364)
Exptl. (n = 3)	Control	+1113 (151-2075)	-1239 (-1452- -1078)	+ 62 (5 -141)
Control (n = 5)	Exptl.	+100 (-103-331)	+42 (-583 - 204)	+241 (-181-714)

(e) Mean change in nitrogen (g/g creatinine)

Exptl. (n = 11)	Exptl.	+2.8 (-6.0-16.3)	-2.4 (-11.0-4.3)	+1.7 (-10.0-11.9)
Exptl. (n = 3)	Control	+6.3 (2.6-10.0)	-8.2 (-10.4- -5.6)	+0.75 (0.6 - 1.0)
Control (n = 5)	Exptl.	-0.4 (-6.2-2.9)	+1.8 (-8.2 - 9.3)	+5.2 (2.6 - 8.8)

* Feeding programme not in operation during period II.
Values are mean with range shown in parentheses.