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A National Nutritional Survey in Ceylon

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It is now generally agreed that there is a relationship between good nutrition and good health, and no description of the health-record of a community would be complete without an accompanying account of the diet and the nutriture of the people.

During the period March 1948 to October 1949, the Physiology Department of the University of Ceylon were engaged in collecting information on the dietary habits of the people of Ceylon. It was originally intended to survey a total sample of 1,400 families, representing about 6,500 people or about one person to every 1,000 persons of the total population according to the 1946 Census. For a number of reasons this figure of 1,400 families was not attained and the final sample comprised 1,307 families and a total of 6,332 persons. This sample was distributed between Urban, Rural and Estate populations, more or less in proportion to the Census figures for these populations, e.g.

	1946 CENSUS POPULATIONS	SURVEY SAMPLE	
		Persons	Families
Urban	1,056,601	1,003	208
Rural	4,725,657	4,511	943
Estate	851,359	818	156
All Ceylon	6,633,617	6,332	1,307

The various racial communities were also represented in the sample in approximate proportion to their total number in the population :—

RACE	PERSONS IN CEYLON	SURVEY SAMPLE	
	(1946) (thousands)	Persons	Families
Sinhalese	4,621	4,419	924
Ceylon Tamils	730	708	146
Indian Tamils	785	765	156
Ceylon Moors	368	396	81

The Ceylon Moors have a greater proportionate representation in the sample than in the actual population, but this was designed deliberately in order to obtain a sufficiently large group of these people.

It was not economically possible to sample an evenly distributed cross-section of the whole population of Ceylon and, instead, representative areas within each district were sampled. For Colombo Town a sample of working and middle class

families was provided by the Director of Census and Statisics and this was supplemented by another sample from the more residential areas of the town. Roughly about one out of every thousand people was included in the sample from each of the four main zones of the island.

ZONE	1946 POPULATION (thousands)	SURVEY SAMPLE Persons	Families
.. ..	2833·6	2,574	638
.. ..	1790·2	1,759	263
C	1135·3	1,095	214
D	898·2	904	192

It is always difficult to estimate the adequacy of a sample and one is always much wiser after a survey is completed than while it is actually being planned. The distribution of the sample between the major communities and the districts of the island seems to be fairly satisfactory ; the distribution between age groups was not so good. As the survey was done on a family basis and not by persons this divergence is not surprising ; the differences however do not appear to be serious (Table 1).

TABLE 1

Age Distribution of Ceylon's Population and of Sample Population.

Age Group	Ceylon (thousands)	Sample
0-4	861·4	796
5-9	811·3	775
10-14	805·6	772
15-44	3140·2	3102
45-54	515·6	392
55 and over	523·2	495

The sample has also been sub-divided according to the economic status of the family. The basis of the classification has been made simply on the income (nonetary and in kind) per adult consumption unit (International values) per month. Three economic levels have been distinguished, viz. :

Economic Level 1 (or the Poor Income Group) in which the families have an income of less than 20 rupees per adult consumption unit per month ;

Economic Level 2 (or the Intermediate Income Group) in which the families have an income of between 20 and 50 rupees per adult consumption unit per month ; and

Economic Level 3 (or the Higher Income Group) in which the families have an income of more than 50 rupees per adult consumption unit per month.

The actual survey was made by the ' family ' method. The survey in each area covered seven consecutive days. Homes were visited three times a day and all foodstuffs were weighed on portable balances to the nearest quarter ounce. The foods were weighed before preparation and cooking, and only the portions to be eaten were weighed.

The details were entered on the family survey form, a specimen of which is given at the end of this paper. The sex and ages of all members of the household consuming food were noted and, in calculating the 'consumption unit value' of the family, notice was taken of any absence from meals or the presence of any guests. Details of the family medical history, race, caste, occupation, income, expenditure, food production and household management were also obtained. The information was checked by consultation with local headmen, Divisional Revenue Officers, etc.

The chemical composition of the diets was calculated from the figures given by :—

1. Platt, B. S.—*Medical Research Council Special Report* 253 of 1945.
2. Nichols, L.—*Tropical Nutrition*, London, 1945.
3. Joachim, A. W. R. and Panditteseker a, D. E.—*Tropical Agriculturist*, 1938.

The international scale of family coefficients (League of Nations, 1932) has been employed in calculating the chemical composition of the diets. This scale is probably not directly applicable to the smaller-bodied tropical races (Bigwood, 1939) but its use enables our results to be compared with those of previous observers. Stiebeling's scale (Stiebeling and Ward, 1933 ; Stiebeling and Phyard, 1939) for the requirements of protein, calcium, phosphorus and iron has also been applied to our family diets. The results obtained by the application of these two scales are expressed 'per consumption unit per day' for each family.

For each community studied, information about the history, organisation and mode of existence of the community was obtained. This information was entered on a Community Survey Form (see specimen) and included such details as the history of the community, genealogies of the inhabitants, family structure, system of land tenure, standards of living, incentives to produce food, incentives to engage in wage labour, methods of distribution and exchange, consumption of food, fluctuations in food intake at various times of the year, food customs, prejudices, taboos or religious customs, native theories of cultivation, principles of soil selection and principles of alternation of crops. Much of this information was obtained from school-masters, headmen, Divisional Revenue Officers and agricultural officers.

A full clinical appraisal was made of as many subjects as were willing to be examined from each community. The Clinical Examination Form shown at the end of this paper gives the scope of this individual survey. In addition estimations of the haemoglobin content of the blood (Sahli's method) were obtained.

In assessing the presence or absence of undernourishment, use was made of the height-weight grid of Wetzel (1941) in addition to noting the usual clinical signs.

The whole survey occupied a period of eighteen months. It was not possible to do all communities at a similar time nor to repeat any community at different periods of the year. The limitations of such a single assessment are realised. As far as possible rural areas were sampled soon after their main paddy harvest and this will have tended to increase the apparent consumption figures for these communities. In other words, for the rural areas, at least, the data will probably represent the maximum consumption of foodstuffs during the year. Another varying factor during the survey was that the food situation within Ceylon gradually improved due to the greater availability and importation of rice. It is not possible to assess

how this may have influenced the findings but it is doubtful whether it can have affected the broad generalisations deduced from the data obtained.

The detailed results for some of the major communities studied have been discussed elsewhere. Here it is only necessary to summarise the findings on a national basis. To do this, the results have been analysed and are presented according to the economic status of the family, the racial-group to which the family belongs and by urban and rural residence.

Economic Status: In each community the quantity and quality of the food eaten is determined to a large extent by the economic status of the family (Tables 2 and 3

TABLE 2

Average Consumption of Foodstuffs by Ceylon People.

The Chemical Composition of the Diet Among 1,307 Families in Ceylon.

(*a*) Average Intakes per Consumption Unit (International Values) per Day.

Chemical Composition	Economic Level 1 441 families		Economic Level 2 681 families		Economic Level 3 185 families	
	Mean daily Consumption	S.e. of Mean	Mean daily Consumption	S.e. of Mean	Mean daily Consumption	S.e. of Mean
Calories	2067	49·5	2593	48·5	3055	93·1
Protein g.	57·8	1·34	75·2	1·63	87·8	2·85
Fat g.	31·8	1·72	52·7	1·68	91·0	4·55
Carbohydrate g.	396	7·1	476	9·7	493	12·0
Calcium mg.	396	14·7	579	13·6	756	24·0
Phosphorus mg.	1475	51·4	1730	51·0	2080	51·7
Iron mg.	12·9	0·39	16·8	0·38	18·1	0·62
Preformed Vitamin A i.u.	3180	103·2	4670	120·2	5700	331·0
Thiamine mg.	0·919	0·027	1·352	0·079	1·365	0·049
Riboflavin mg.	1·433	0·058	2·052	0·044	2·321	0·038
Nicotinic Acid mg.	11·02	0·587	13·00	0·288	13·62	0·464
Ascorbic Acid mg.	48·1	2·99	51·0	1·67	90·5	4·42

(*b*) Average Intakes per Consumption Unit (Stiebeling Values) per Day.

Chemical Composition	Economic Level 1		Economic Level 2		Economic Level 3	
	Mean daily Composition	S.e. of Mean	Mean daily Composition	S.e. of Mean	Mean daily Composition	S.e. of Mean
Protein g.	47·5	1·26	61·2	1·13	73·9	2·03
Calcium mg.	256	11·2	366	10·3	527	23·4
Phosphorus mg.	1296	46·2	1430	35·2	1860	66·5
Iron mg.	11·7	0·34	14·9	0·30	16·2	0·54

S.e. = Standard Error, i.u. = International Unit.

TABLE 3

The Consumption of Various Foodstuffs in Ceylon.
Average Daily Intakes (oz.) per Consumption Unit (International Value).

	Foodstuffs	Economic Level 1 441 families		Economic Level 2 681 families		Economic Level 3 185 families	
		Mean	S.e.	Mean	S.e.	Mean	S.e.
Cereals	Rice	9·95	0·31	11·22	0·26	10·80	0·73
	Wheat Flour	2·96	0·044	4·27	0·092	3·69	0·124
	Other Cereals	1·59	0·068	0·996	0·053	0·07	0·180
Vegetables	Roots	1·65	0·036	1·26	0·063	2·16	0·102
	Greens	1·37	0·064	2·08	0·122	1·32	0·963
	Pulses	0·582	0·051	1·33	0·079	0·517	0·082
	Vegetable Fruits	2·00	0·196	1·39	0·140	2·96	0·266
Fruit	Fresh	0·494	0·073	0·401	0·045	1·42	0·161
Dairy Products	Fresh Milk	0·470	0·120	1·25	0·141	3·19	0·345
	Powdered Milk	0·042	0·006	0·111	0·024	0·24	0·053
	Butter	—	—	0·021	0·0043	0·31	0·028
	Ghee & Curd	0·01	0·0006	0·004	0·0023	0·128	0·016
	Eggs	0·017	0·0053	0·047	0·0069	0·372	0·040
	Meat	1·63	0·20	3·05	0·15	10·15	0·27
	Fish	14·1	0·30	16·44	0·32	22·81	0·89

S.e. = Standard Error of Mean.

The calorific value of the total foodstuffs consumed, and the total amounts of the individual chemical contents consumed increase with increasing economic status of the consumers. The variation in the consumption of individual foodstuffs with economic level is not so consistent. In general, the economic level 2 families eat more cereals, green vegetables and pulses while the higher economic level 3 families eat more root vegetables, fresh fruit, dairy products, meat and fish.

The proportions of the average total calories derived from protein, from carbohydrate and from rice decrease while the proportion contributed by fat increases with rising economic status (Table 4).

TABLE 4

Percentage of total calories derived from—

	Protein	Fat	Carbohydrate	Rice
Economic Level 1	14·1	14·3	71·6	48·1
Economic Level 2	12·2	18·9	68·9	43·3
Economic Level 3	11·7	27·7	60·6	36·3

The high contributions made by total carbohydrate and by rice in particular illustrate the lack of variety in the diet of the average Ceylonese. This is further shown by the meagre quantities of milk, butter and other dairy products consumed by the people at all economic levels. Actually only a small number of families were found to consume these foodstuffs, the proportion rising with economic status (Table 5).

TABLE 5

Proportion of Families consuming—

	Butter	Milk	Milk Powder	Ghee	Eggs
Economic Level 1	7/441	83/441	17/441	3/441	27/441
Economic Level 2	24/681	288/681	103/681	28/681	154/681
Economic Level 3	51/185	161/185	52/185	31/185	93/185

The consumption of meat is also very small, although fish is a common article of the diet. Therefore most of the protein of the diets was of vegetable origin (Table 6). The percentage contribution to the total protein intake made by meat increases with rising economic level, but the average contribution to the total intake made by fish is more or less the same at each economic level.

TABLE 6

Percentage of total Proteins contributed by—

	Meat	Fish	Vegetables
Economic Level 1	2·8	24·4	72·8
Economic Level 2	4·1	21·9	74·0
Economic Level 3	11·2	25·1	63·7

Many previous investigators have commented upon the influence of economic or social status upon the nutritional adequacy of the diet. It is true for Western countries (Orr, 1937; McCance, Widdowson and Vandon-Roe, 1938), for India (Wilson and Widdowson, 1942) and Ceylon (Bibile *et al*, 1949).

The assessment of the adequacy of a diet in the tropics is difficult because of the lack of any real scientific basis for the suggested requirements of people in the tropics. Standard requirements have usually been based upon the allowances suggested for Western peoples, although requirements for India (Bigwood, 1939) and for Ceylon (Nichols, 1945) have been tentatively computed. On the basis of our own observations on the basal metabolic rate of the smaller-bodied Ceylonese, and from the results of mineral balance studies, we have suggested the following minimum daily dietary allowances per adult Ceylonese man (Cullumbine, 1949):—

Calories	2,200 (labourer 2,500)
Protein	65 g.
Calcium	500 mg.
Iron	15 mg.
Vitamin A	10,000 i.u. as carotene
Thiamine	1·2 mg.

Riboflavin	..	..	..	1·5 mg.
Nicotinic Acid	..	..	..	12 mg.
Vitamin C	..	..	..	40 mg.

Comparing these standards with the figures given in Table 1, we can conclude that the average diet of the families from economic level 1 is deficient in total calories, protein, calcium, iron, and at least the vitamin A, thiamine, riboflavin, and nicotinic acid. At economic level 2 and 3, the average diets are deficient only in vitamin A. This again stresses the marked influence of economic status upon the nutritional adequacy of the diet.

A more detailed appraisal of the diets can be obtained by using our standards to assess the diets of individual families at each economic level (Table 7). Again, the influence of economic status on the diet is evident since the higher the family income the greater is the tendency for the diet to be adequate.

TABLE 7

Economic Level	Number of Families	The Number of Families with Adequate Dietary Intake of							
		Calories	Protein	Calcium	Vitamin A	Vitamins Thiamine	Riboflavin	Nicotinic Acid	Ascorbic Acid
1	441	158	181	139	45	157	147	95	212
2	681	406	460	366	189	464	427	214	364
3	185	142	151	143	26	117	139	101	161

The suggested calcium requirement (500 mg.) is low when compared with that recommended (800 mg.) by the National Research Council (1945) but it must be remembered that the latter figure was suggested for American people, who are much taller and heavier than the average Ceylonese (mean adult weight at 21 years only 50 kg.). Even using this lower calcium requirement as a standard, many of the families surveyed had inadequate intakes. Despite this, signs of bony abnormalities due to nutritional deficiencies are rare in Ceylon. The Ceylonese diet contains practically no vitamin D but presumably this does not matter since Ceylon is a country with perpetual sunshine. Eliot (1933) and Wilson and Widdowson (1942) have already suggested that rickets and osteomalacia only occur where a vitamin D deficiency is superimposed on a calcium deficiency, but evidence of the occurrence of osteoporosis might have been expected. Perhaps the answer is to be found in the results obtained from calcium balance studies on rice diets (Cullumbine *et al*, 1950). These experiments revealed that the body can adapt itself to relatively low intakes of available calcium so that more efficient utilization of the calcium in the diet is obtained.

Many of the individual members of families surveyed were examined clinically and, in this way, an indication of the incidence of the signs of deficient nutrition has been obtained (Table 8). [An appraisement of the signs upon which this assessment was based is to be published later].

Signs of undernourishment, xerosis, ariboflavinosis and of anaemia are to be found more frequently in the people living at the lowest economic level. By contrast, the incidence of dental caries is similar at each economic level while phrynoderma (follicular hyperkeratosis) is greatest among people from economic level 2.

TABLE 8

Economic Level	Number of subjects examined	Number of subjects with signs of					
		Under-Nourishment	Xerosis	Phrynoderma	Aribo-flavinosis	Anaemia	Dental Caries
1	1936	575	1119	629	107	1141	697
2	2876	367	1099	1252	108	1066	908
3	583	79	243	173	3	102	182

Xerosis, xereophthaemia and Bitot's spots may be taken as evidence of vitamin A deficiency and the latter is the major nutritional deficiency in Ceylon. Over 90 per cent. of the vitamin A of the Ceylonese diet comes from the β-carotene of vegetables and vegetable fruits. If the availability correction factors for vitamin A, suggested by Hume and Krebs (1949) also apply to Ceylon foodstuffs and if we accept the requirements suggested by Hume and Krebs, then the Ceylonese diet should contain about 10,000 i.u. of β-carotene (this has been discussed at some length elsewhere, see Cullumbine *et al*, 1950). This is far in excess of the calculated intake for meat of the families surveyed so that it is not surprising to find such a high incidence of signs of vitamin A deficiency. There is no doubt that the general deficiency throughout Ceylon is due to the fact that liver, milk, cheese, butter, fish-oils, eggs, etc. are not consumed in any measurable quantities by the average Ceylonese. The main oil used in the diet is coconut oil which is devoid of vitamin A activity and, as noted, the chief source is the carotene of vegetables and vegetable fruits. Because of the low available potency of this carotene, large amounts of these foodstuffs need to be consumed to obtain an adequate intake of this vitamin.

The causation of phrynoderma is still disputed (Wilson and Widdowson 1942; Bibile *et al*, 1949) and Stannus (1945) and Hume and Krebs (1949) have concluded that the tendency to develop keretinized hair follicles is not specifically related to the vitamin A nutrition. Our own observations support these conclusions (Cullumbine *et al*, 1950).

Although many of the diets were apparently inadequate in their thiamine, riboflavin, nicotinic acid or ascorbic acid content, yet the incidence of the signs of deficiency of these vitamins was low.

Many of the families had a low iron intake and, if 10 g. haemoglobin/100 c.c. blood be taken as the minimum level in adults, then anaemia is very common in Ceylon. There was no statistically significant correlation between iron intake and blood haemoglobin level, although those subjects with a haemoglobin concentration greater than 10 g./100 c.c. had a higher mean daily iron intake (14·2 mg. ± 0·31) than the subjects with less than this haemoglobin level (11·5 mg. ± 0·27). Malaria, hookworm infestation, etc., may be important in determining the high incidence of anaemia, but, although anaemic people absorb a greater proportion of their iron intake than do normal people, the lower average iron content of the diet of the anaemic people may be a perpetuating factor.

The survey data have also been analysed according to the racial grouping in Ceylon, families at each of our economic levels being considered separately. The general remarks already made about the influence of economic status on the food intake apply with equal emphasis for each racial community (Table 9).

TABLE 9

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 1

(*a*) Average Intakes per Consumption Unit (International Values) per Day.

Chemical Composition	Sinhalese 344 families		Ceylon Tamil 56 families		Indian Tamil 4 families		Ceylon Moor 37 families	
	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.
Calories	2163	56·9	2219	138·0	1540	—	1407	114·4
Protein g.	59·8	1·9	59·4	4·45	55·5	—	37·4	3·19
Fat g.	39·8	1·9	50·5	7·16	18·8	—	26·3	3·46
Carbohydrate g.	407·4	11·1	401·7	18·2	303	—	296	19·1
Calcium mg.	425·4	15·6	290·9	36·3	341	—	297	28·8
Phosphorus mg.	1510	58·4	1646	78·7	1659	—	890	80·1
Iron mg.	13·9	0·44	11·18	0·90	12·4	—	7·1	1·06
Preformed Vitamin A. i.u.	3526	137·2	2359	428·6	2420	—	1320	448·6
Thiamine mg.	0·965	0·091	0·818	0·068	0·673	—	0·667	0·063
Riboflavin mg.	1·610	0·051	1·016	0·060	0·862	—	0·620	0·281
Nicotinic Acid mg.	10·80	0·328	10·75	0·641	6·55	—	14·1	0·613
Ascorbic Acid mg.	51·6	1·92	40·29	7·05	20·7	—	31·6	3·58

S.e. = Standard Error of Mean.
i.u. = International Unit.

TABLE 9 (*Contd*).

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 1

(*b*) Average Intakes per Consumption Unit (Stiebeling Values) per Day.

Chemical Composition	Sinhalese 344 families		Ceylon Tamil 56 families		Indian Tamil 4 families		Ceylon Moor 37 families	
	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.
Protein g.	49·2	1·29	48·5	3·15	43·4	—	30·6	3·21
Calcium mg.	271·7	11·5	198·5	36·3	505	—	181	21·4
Phosphorus mg.	1329	40·1	1425	104·3	1321	—	814	72·3
Iron mg.	12·61	0·34	10·11	0·77	10·1	—	6·36	0·92

S.e. = Standard Error of Mean.
i.u. = International Unit.

TABLE 9

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 2

(*a*) Average Intakes per Consumption Unit (International Values) per Day.

Chemical Composition	Sinhalese 447 families		Ceylon Tamil 58 families		Indian Tamil 150 families		Ceylon Moor 26 families	
	Mean daily Consumption	S.e.	Mean daily Consumption	S.e.	Mean daily Consumption	S.e.	Mean daily Consumption	S.e.
Calories	2469	44·0	2500	114·4	3030	55·7	2151	193·6
Protein g.	74·3	1·19	75·0	4·19	79·5	1·90	63·5	6·76
Fat g.	49·7	1·53	62·0	3·56	58·2	2·14	51·7	5·81
Carbohydrate g.	454	6·3	431	20·1	577	8·6	376	23·9
Calcium mg.	600	13·1	410	28·8	610	23·6	415	43·6
Phosphorus mg.	1·580	45·6	1·935	84·1	2.101	43·0	1·718	91·8
Iron mg.	16·62	0·35	14·6	1·06	19·3	0·49	10·53	0·96
Preformed Vitamin A, i.u.	5090	91·5	4007	288·6	4060	147·1	2390	219·8
Thiamine mg.	1·300	0·024	1·411	0·073	1·551	0·079	0·95	0·110
Riboflavin mg.	2·124	0·052	1·408	0·281	2·292	0·072	0·906	0·074
Nicotinic Acid mg.	13·62	0·433	12·89	0·783	11·41	0·202	11·55	1·14
Ascorbic Acid mg.	53·2	2·66	61·3	5·58	40·8	2·97	50·0	3·12

TABLE 9 (*Contd.*)

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 2

(*b*) Average Intakes per Consumption Unit (Stiebeling Values) per Day.

Chemical Composition	Sinhalese 447 families		Ceylon Tamil 58 families		Indian Tamil 150 families		Ceylon Moor 26 families	
	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.
Protein g.	58·2	1·13	68·8	3·45	68·3	1·70	58·2	4·44
Calcium mg.	370	10·0	298	60·0	401	16·3	269	23·0
Phosphorus mg.	1295	41·1	1779	65·1	1680	29·2	1535	80·1
Iron mg.	14·70	0·31	14·02	0·91	16·65	0·42	10·44	0·97

S.e. = Standard Error of Mean.
i.u. = International Units.

TABLE 9

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 3

(*a*) Average Intakes per Consumption Unit (International Values) per Day.

Chemical Composition	Sinhalese 130 families		Ceylon Tamil 32 families		Indian Tamil 2 families		Ceylon Moor 18 families	
	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.
Calories	3112	106·1	2886	171·2	3905	—	2842	229·5
Protein g.	88·5	3·25	826·6	5·05	110·0	—	80·8	6·97
Fat g.	91·6	5·19	91·1	10·5	65·1	—	88·1	13·7
Carbohydrate g.	506	13·7	449	24·9	760	—	451	32·9
Calcium mg.	812	27·3	595	43·2	1315	—	580	57·5
Phosphorus mg.	1960	59·0	2345	137·2	3858	—	2350	190·7
Iron mg.	18·85	0·71	15·75	1·26	21·2	—	16·6	1·36
Preformed Vitamin A. i.u.	5910	377	5220	321	5463	—	5140	333
Thiamine mg.	1·470	0·056	1·109	0·075	0·932	—	1·140	0·095
Riboflavin mg.	2·568	0·043	1·808	0·167	1·031	—	1·583	0·213
Nicotinic Acid mg.	13·80	0·529	13·10	0·956	11·57	—	13·60	1·14
Ascorbic Acid mg.	91·5	5·05	92·5	8·21	44·6	—	83·7	10·5

S.e. = Standard Error of Mean.
i.u. = International Unit.

TABLE 9 (*Contd.*)

The Chemical Composition of the Diet Among

ECONOMIC LEVEL 3

(*b*) Average Intakes per Consumption Unit (Stiebeling Values) per Day.

Chemical Composition	Sinhalese 130 families		Ceylon Tamil 32 families		Indian Tamil 2 families		Ceylon Moor 18 families	
	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.	Mean daily consumption	S.e.
Protein g.	73·1	2·32	75·4	3·96	110·0	—	74·0	5·34
Calcium mg.	575	26·6	388	27·4	1270	—	340	36·5
Phosphorus mg.	1668	76·0	2120	104·8	5450	—	2100	144·6
Iron mg.	16·7	0·62	15·1	0·95	20·7	—	14·1	1·13

S.e. = Standard Error of Mean.
i.u. = International Unit.

The inferior quality and quantity of the diet consumed by the Ceylon Moors is note-worthy. In general, the average diet of the Ceylon Moors has a lower calorie-value and contains less protein, fat and carbohydrate than does the average diet of the Ceylon Tamil and the Sinhalese and this is more or less true at all three economic levels. Their diet also has relatively low contents of calcium, iron and the principal vitamins (except nicotinic acid).

Most of the Indian Tamil families in the survey group belonged to the intermediate economic level 2 and here their average diet was superior to those of the other racial groups in its calorie-value, protein and carbohydrate contents, and in the calculated amounts of iron, calcium, thiamine and riboflavin present. The Indian Tamil diet is, however, relatively poor in vitamin A, nicotinic acid and ascorbic acid.

The diet of the Ceylon Tamil is richer in fat than the other diets and poorer in calcium. Since this diet has a high phosphorus content, the calcium/phosphorus ratio of the Ceylon Tamil diet is very low. The Sinhalese diet contains greater quantities of calcium, iron, vitamin A, thiamine (except at economic level 2), riboflavin and nicotinic acid than does the Ceylon Tamil diet. The proportion of families within each community with adequate dietary intakes reflects the above differences (Table 10).

These differences in the chemical composition of the diets are due, of course, to differences in the composition of various foodstuffs by the different communities (Table 11).

For example, the Moors have low average consumption of wheat flour, all types of vegetables and fruits, meat and (except for ghee and for families at economic level 2) all forms of dairy produce. The Indian Tamil has a relatively high consumption of rice, wheat flour and of pulses but consumes hardly any dairy products (except fresh milk) and little meat and fish. The Ceylon Tamil tends to eat more rice but less of other cereals than does the Sinhalese. The latter eat more vegetables, milk and meat but less fruit (except at economic level 3) than the Ceylon Tamil.

The different diets of these racial communities in Ceylon produce different incidences of deficiency-syndromes (Table 12).

A greater portion of Ceylon Moors were undernourished than the other races in each economic group. In addition xerosis was commoner among the Moors but no phrynoderma was seen among Moors living at economic level 3. For all communities, except the Ceylon Tamil, phrynoderma was commonest among subjects living at economic level 2 ; in the case of the Ceylon Tamil the incidence among this group was lower than among Tamils in the other economic groups. Signs of ariboflavinosis were much the more common, however, among the Ceylon Tamils while the incidence of anaemia was very high among the Ceylon Moors. The good dental health of the Ceylon Tamils is striking, especially when the low calcium content of their diets is remembered.

In general, there is a close correspondence between the calculated average compositions of the diets and the incidence of signs of nutritional deficiency.

TABLE 10

The Number of Families Among Different Communities in Ceylon with Adequate Dietary Intakes.

Economic Level	Community	Number of Families Examined	Number of Families with Adequate Intakes of—							
			Calories	Protein	Calcium	Vitamin A	Thiamine	Riboflavin	Nicotinic acid	Ascorbic acid
1	Sinhalese	344	135	158	128	40	108	134	86	181
	Ceylon Tamil	56	20	19	5	4	21	10	7	21
	Indian Tamil	4	1	2	2	—	2	1	1	—
	Ceylon Moor	37	2	2	4	1	26	2	1	10
2	Sinhalese	447	272	312	241	116	309	297	182	268
	Ceylon Tamil	58	19	26	6	3	14	19	8	36
	Indian Tamil	150	104	110	110	63	127	104	17	46
	Ceylon Moor	26	11	12	9	7	14	7	7	14
3	Sinhalese	133	111	116	118	19	98	116	75	121
	Ceylon Tamil	32	19	21	15	3	12	16	16	25
	Indian Tamil	2	2	2	2	3	—	—	—	2
	Ceylon Moor	18	10	12	8	2	7	7	10	13

TABLE 11

The Consumption of Various Foodstuffs Among Different Communities in Ceylon. Average Daily Intakes (oz.) per Consumption Unit (International Values).

ECONOMIC LEVEL 1

	Foodstuffs	Sinhalese 344 families		Ceylon Tamil 56 families		Indian Tamil 4 families		Ceylon Moor 37 families	
		Mean	S.e.	Mean	S.e.	Mean	S.e.	Mean	S.e.
Cereals	Rice	9·31	0·36	13·37	0·70	10·2	—	10·5	0·64
	Wheat Flour	3·55	0·051	1·23	0·099	3·3	—	0·15	0·031
	Other Cereals	1·97	0·077	—	—	—	—	0·59	0·013
Vegetables	Roots	1·98	0·041	0·61	0·079	0·46	—	0·31	0·024
	Greens	1·38	0·036	1·63	0·142	1·30	—	0·91	0·084
	Pulses	0·68	0·066	0·23	0·115	1·21	—	0·15	0·035
	Vegetable Fruits	2·44	0·22	0·55	0·149	—	—	0·27	0·042
Fruit	Fresh	0·51	0·083	0·64	0·123	0·14	—	0·18	0·005
Dairy Products	Fresh Milk	0·56	0·137	0·09	0·006	0·33	—	0·23	0·082
	Powdered Milk	0·05	0·007	0·02	0·004	—	—	—	—
	Butter	—	—	—	—	—	—	—	—
	Ghee and Curd	—	—	0·01	0·003	—	—	0·101	0·005
	Eggs	0·01	0·0061	0·01	0·002	0·83	—	—	—
Protein g.	Meat	1·73	0·16	1·97	0·13	—	—	0·37	0·056
	Fish	14·83	0·27	12·68	0·31	6·14	—	10·22	0·614

S.e. = Standard Error of Mean.

TABLE 11 (*Contd.*)

The Consumption of Various Foodstuffs Among Different Communities in Ceylon.
Average Daily Intakes (oz.) per Consumption Unit (International Values).

ECONOMIC LEVEL 2

	Foodstuffs	Sinhalese 447 families		Ceylon Tamil 58 families		Indian Tamil 150 families		Ceylon Moor 26 families	
		Mean	S.e.	Mean	S.e.	Mean	S.e.	Mean	S.e.
Cereals	Rice	10·32	0·21	12·61	0·63	13·30	0·43	12·13	0·84
	Wheat Flour	4·24	0·074	1·81	0·192	5·30	0·151	0·93	0·251
	Other Cereals	1·51	0·043	0·01	0·127	0·01	0·092	0·08	0·024
Vegetables	Roots	1·46	0·051	0·81	0·151	0·92	0·101	0·70	0·210
	Greens	2·15	0·095	1·69	0·232	2·13	0·175	1·29	0·391
	Pulses	0·97	0·063	0·27	0·018	3·03	0·131	0·18	0·254
	Vegetable Fruits	1·93	0·125	1·10	0·235	—	—	0·84	0·235
Fruit	Fresh	0·42	0·037	0·76	0·091	0·26	0·023	0·10	0·039
Dairy Products	Fresh Milk	1·32	0·110	0·88	0·231	1·16	0·025	1·36	0·076
	Powdered Milk	0·14	0·022	0·16	0·047	—	—	0·14	0·008
	Butter	0·03	0·004	0·01	0·007	—	—	—	—
	Ghee and Curd	—	—	0·01	0·0006	—	—	0·09	0·007
	Eggs	0·06	0·005	0·05	0·010	—	—	0·09	0·011
Protein g.	Meat	4·07	0·16	2·55	0·23	0·13	0·08	0·82	0·11
	Fish	20·89	0·23	20·85	0·36	0·80	0·12	20·21	0·37

S.e. = Standard Error of Mean.

TABLE 11 (*Contd.*)

The Consumption of Various Foodstuffs Among Different Communities in Ceylon.
Average Daily Intakes (oz.) per Consumption Unit (International Values).

ECONOMIC LEVEL 3

	Foodstuffs	Sinhalese 133 families		Ceylon Tamil 32 families		Ceylon Moor 18 families	
		Mean	S.e.	Mean	S.e.	Mean	S.e.
Cereals	Rice	9·55	0·59	12·91	1·63	13·45	1·94
	Wheat Flour	4·41	0·36	2·18	0·381	1·51	0·473
	Other Cereals	0·09	0·008	0·03	0·002	0·03	0·006
Vegetables	Roots	2·62	0·081	1·16	0·162	0·74	0·194
	Greens	1·61	0·055	0·61	0·073	0·57	0·079
	Pulses	0·54	0·065	0·51	0·130	0·41	0·183
	Vegetable Fruits	3·42	0·212	1·90	0·513	1·68	0·614
Fruit	Fresh	1·77	0·131	0·72	0·251	0·27	0·192
Dairy Products	Fresh Milk	3·52	0·312	2·66	0·613	2·06	0·512
	Powdered Milk	0·25	0·042	0·25	0·092	0·18	0·061
	Butter	0·39	0·021	0·13	0·051	0·07	0·003
	Ghee and Curd	0·06	0·003	0·15	0·033	0·71	0·065
	Eggs	0·45	0·032	0·19	0·034	0·11	0·062
Protein	Meat	12·00	0·21	6·34	0·43	4·42	0·57
	Fish	22·80	0·61	23·61	0·97	23·80	1·68

S.e. = Standard Error of Mean.

TABLE 12

Number of Subjects Among the Different Communities in Ceylon with signs of Deficient Nutrition.

Economic Level	Community	Number of Subjects Examined	Number found with signs of—					
			Under-nourish-ment	Xerosis	Phryno-derma	Ariboflavin	Anaemia	Dental Caries
1	Sinhalese	1518	433	803	507	35	715	610
	Ceylon Tamil	289	74	222	97	67	216	53
	Indian Tamil	11	4	7	5	4	4	1
	Ceylon Moor	118	64	87	40	1	106	33
2	Sinhalese	1726	225	554	807	33	560	671
	Ceylon Tamil	299	55	94	44	24	88	32
	Indian Tamil	754	57	403	360	47	336	164
	Ceylon Moor	97	30	48	41	4	82	41
3	Sinhalese	388	49	111	97	—	36	146
	Ceylon Tamil	102	12	42	24	3	12	3
	Indian Tamil	3	—	—	—	—	—	3
	Ceylon Moor	90	18	52	—	—	54	30

The Indian Tamils were all estate labourers or their families. The other communities were distributed between the urban and rural populations and the data can be analysed into urban, rural and estate families (Table 13).

TABLE 13

The Chemical Composition of the Diets of Urban, Rural and Estate Populations in Ceylon.

ECONOMIC LEVEL 1

(*a*) Average Intakes per Consumption Unit (International Value) per Day.

Chemical Composition	Urban 63 families		Rural 364 families		Estate 4 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Calories	2062	94·1	1852	40·7	1540	—
Protein g.	61·3	2·57	57·4	1·10	55·5	—
Fat g.	44·1	3·03	38·9	1·36	18·8	—
Carbohydrate g.	377	14·5	332	5·7	303	—
Calcium mg.	319	16·2	416	12·2	341	—
Phosphorus mg.	1219	87·6	1516	41·1	1659	—
Iron mg.	12·3	0·71	13·2	0·36	12·4	—
Vitamin A. i.u.	3790	213·8	3120	84·9	2420	—
Thiamine mg.	0·866	0·059	0·937	0·026	0·673	—
Riboflavin mg.	1·905	0·106	1·400	0·048	0·862	—
Nicotinic Acid mg.	11·99	0·993	10·96	0·392	6·55	—
Ascorbic Acid mg.	43·3	5·62	49·6	2·41	20·7	—

(*b*) Average Intakes per Consumption Unit (Stiebeling Value) per Day.

Chemical Composition	Urban 63 families		Rural 364 families		Estate 4 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Protein g.	46·7	2·32	47·9	1·02	43·4	—
Calcium mg.	200	19·7	267	8·9	505	—
Phosphorus mg.	991	81·4	1350	41·4	1321	—
Iron mg.	10·7	0·66	12·1	0·28	10·1	—

S.e. = Standard Error of Mean.
i.u. = International Unit.

TABLE 13 (*Contd.*)

The Chemical Composition of the Diets of Urban, Rural and Estate Population in Ceylon.

ECONOMIC LEVEL 2

(*a*) Average Intakes per Consumption Unit (International Value) per Day.

Chemical Composition	Urban 97 families		Rural 434 families		Estate 150 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Calories	2440	112·3	2500	40·1	3030	55·7
Protein g.	80·4	3·4	72·3	1·3	79·5	1·90
Fat g.	37·4	3·5	49·7	1·4	58·2	1·14
Carbohydrate g.	449	18·2	448	7·8	577	8·6
Calcium mg.	479	243	594	10·9	610	23·6
Phosphorus mg.	1470	101·7	1660	40·4	2101	43·0
Iron mg.	15·7	0·93	16·3	0·33	19·3	0·49
Vitamin A. i.u.	5870	292·6	4620	96·4	4060	147·1
Thiamine mg.	1·181	0·183	1·212	0·064	1·551	0·079
Riboflavin mg.	2·320	0·106	1·92	0·036	2·292	0·072
Nicotinic Acid mg.	14·88	0·709	10·9	0·230	11·41	0·202
Ascorbic Acid mg.	60·1	3·88	52·5	1·35	40·8	2·97

(*b*) Average Intakes per Consumption Unit (Stiebeling Value) per Day.

Chemical Composition	Urban 97 families		Rural 434 families		Estate 150 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Protein g.	61·3	2·71	57·9	0·91	68·3	1·70
Calcium mg.	308	23·3	37·0	8·2	401	16·3
Phosphorus mg.	1220	74·5	1392	29·3	1680	29·2
Iron mg.	14·0	0·62	14·6	0·40	16·65	0·42

S.e. = Standard Error of Mean.
i.u. = International Unit.

TABLE 13 (*Contd.*)

The Chemical Composition of the Diets of Urban, Rural and Estate Populations in Ceylon.

ECONOMIC LEVEL 3

(*a*) Average Intakes per Consumption Unit (International Values) per Day.

Chemical Composition	Urban 48 families		Rural 135 families		Estate 2 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Calories	2980	149·1	3060	88·0	3905	—
Protein g.	83·8	5·02	86·0	4·15	110·0	—
Fat g.	92·9	8·31	89·9	6·26	65·1	—
Carbohydrate g.	469	20·7	491	14·4	760	—
Calcium mg.	741	39·8	749	28·5	1315	—
Phosphorus mg.	1975	84·2	2059	72·4	3858	—
Iron mg.	17·9	1·15	17·8	0·72	21·2	—
Vitamin A. i.u.	5820	543·6	5600	463·4	5463	—
Thiamine mg.	1·360	0·093	1·372	0·062	0·932	—
Riboflavin mg.	2·361	0·074	2·320	0·055	1·031	—
Nicotinic Acid mg.	13·22	0·756	13·60	0·431	11·57	—
Ascorbic Acid mg.	93·5	7·21	89·5	6·18	44·6	—

(*b*) Average Intakes per Consumption Unit (Stiebeling Values) per Day.

Chemical Composition	Urban 48 families		Rural 135 families		Estate 2 families	
	Mean	S.e.	Mean	S.e.	Mean	S.e.
Protein g.	70·4	3·40	73·2	2·17	110·0	—
Calcium mg.	519	38·8	515	33·4	1270	—
Phosphorus mg.	1744	107·8	1780	98·1	5450	—
Iron mg.	16·0	0·99	16·1	0·72	20·7	—

S.e. = Standard Error of Mean.
i.u. = International Unit.

The average calorie-value of the diet of the urban population is greater than that for the diet of the rural populations living at the lowest economic level, but at both economic levels 2 and 3 the calorie values are similar for the diets of the two types of communities. The diets of the people living at the higher economic level have, indeed, very similar chemical compositions in both rural and urban areas. People living in urban communities and at economic levels 1 and 2 have smaller average daily intakes of minerals, thiamine and ascorbic acid and greater intakes of vitamin A, riboflavin and nicotinic acid than do the corresponding people in rural communities.

The estate population belongs in the main to our economic level 2, and here their average diet is superior in most respects to the diets of urban and rural populations. The exceptions are the relatively low contents of vitamin A, nicotinic acid and vitamin C in the estate diet. A smaller proportion of the estate families, similarly, had adequate intakes of nicotinic acid and vitamin C, and a larger proportion than in urban and rural areas had adequate consumptions of protein, calcium, riboflavin and even of vitamin A (Table 14).

For people living at economic levels 1 and 2, a larger proportion of urban than rural families had adequate diets in respect of calories, protein, vitamin A, riboflavin, nicotinic acid and vitamin C contents, the rural diets being more often adequate in their calcium and thiamine values.

These variations in the chemical compositions of the different diets are paralleled by the incidence of signs of nutritional deficiencies in the three communities. The rural population in the two lower income groups has a higher incidence of undernourishment, xerosis and anaemia than the urban population. The estate population has a relatively high proportion of people suffering from anaemia but gives less evidence of undernourishment and xerosis. Dental caries, at all economic levels, occurs most frequently among the urban population (Table 15).

The general nutritional picture in Ceylon is, therefore, one with many deficiencies. Carbohydrate foods and especially rice supply the bulk of the energy but many of the diets are deficient in calorie-value and undernourishment is common among the population. The protein is derived chiefly from vegetable sources. Especially among people in the lower economic groups the total protein intake is low. (It is usually assumed that animal proteins have a higher biological value than vegetable proteins but a proper mixture of plant proteins may be adequate for maintenance and growth. Until more is known about the amino-acid requirements of man and the availability to man of amino-acids from various mixtures of animal and vegetable proteins, it is difficult to assess the adequacy of these diets). Most of the diets also contain low amounts of calcium and vitamin A. It is rare to find signs of bony changes due to deficient nutrition but ocular signs of vitamin A deficiency are very common.

The average diet of the Ceylon Moors is poorer than that of any other racial group in Ceylon, and, in general, the average Sinhalese has a better diet than the Ceylon Tamil. The Indian Tamil diet is better still except for its contents of vitamin A, nicotinic acid and ascorbic acid.

Signs of undernourishment, xerosis and anaemia are commoner among the Ceylon Moors and ariboflavinosis occurs most frequently among Ceylon Tamils. The latter, however, have the lowest incidence of dental caries, which is also less common among the rural population. With the exceptions of the calcium and thiamine contents, the diet of the rural population is inferior to that of the urban population.

The calculated contents of the B group vitamins in the various diets are often low but yet signs due to deficiency of one or other of these vitamins are not common. It is possible that a people, who for generations have existed on a multiple-deficient diet, may have developed some degree of adaptation which has enabled them to grow and mature on much smaller intakes of protein, calcium and vitamins than those normally required by Western people. Alternatively, since Hume and Krebs (1949)

TABLE 14

The Number of Families Among Urban, Rural and Estate Communities in Ceylon with Adequate Dietary Intakes.

Economic Level	Community	Number of Subjects Examined	Number of Families with Adequate Intakes of—							
			Calories	Protein	Calcium	Vitamin A	Thiamine	Riboflavin	Nicotinic Acid	Ascorbic Acid
1	Urban	63	28	32	8	8	18	34	25	31
	Rural	374	129	147	129	37	137	112	69	181
	Estate	4	1	2	2	—	2	1	1	—
2	Urban	97	62	72	37	29	59	72	47	68
	Rural	434	240	278	219	97	278	251	160	260
	Estate	150	104	110	110	63	127	104	17	46
3	Urban	48	37	40	38	5	33	41	26	45
	Rural	135	103	109	103	19	84	98	75	114
	Estate	2	2	2	2	2	—	—	—	2

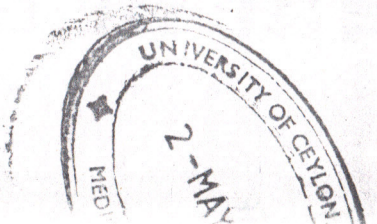

TABLE 15

Number of Subjects Among Urban, Rural and Estate Communities in Ceylon with signs of Deficient Nutrition.

Economic Level	Community	Number of Subjects Examined	Number Found with Signs of—					
			Under-nourish-ment	Xerosis	Phryno-derma	Aribo-flavinosis	Anaemia	Dental Caries
1	Urban	277	68	137	76	11	143	274
	Rural	1648	503	975	548	92	994	422
	Estate	11	4	7	5	4	4	1
2	Urban	440	43	125	130	12	149	305
	Rural	1682	267	571	762	49	581	439
	Estate	754	57	203	360	47	336	164
3	Urban	153	21	60	41	1	28	62
	Rural	427	56	183	132	2	74	120
	Estate	3	—	—	—	—	—	3

have indicated that the potency of carotene in the diet varies with the type of foodstuffs consumed, it may be that the potency or the availability of other vitamins may also depend upon the types of foodstuffs and that the food in the Ceylon diet are especially potent. There is no evidence that this is so.

The estimated nutritive values of the Ceylon diets assessed during this survey are surprisingly small by Western standards. This may be due to several factors. There is an overall shortage of available foodstuffs in Ceylon (Cullumbine, 1949). And the average Ceylonese cannot afford or, because of unequal distribution, is unable to obtain a full choice of foodstuffs. In addition the village cultivator tends to concentrate his main effort on the production of rice. However, even healthy boys and girls in Ceylon, whose parents have a sufficient income to provide them with an adequate diet, eat much less than do children of similar ages in Britain.

In May, 1949, 300 middle and upper class Ceylon Tamil school boys, ages ranging from 8 to 19 years, weighed their food for 7 consecutive days. Each yearly age group comprised 25 schoolboys and each boy was medically examined and his home was visited during the week of weighing.

The mean chemical composition of the daily diets of each group of boys have been calculated (Table 16) and those can be compared with the results obtained by Widdowson (1947) from a similar individual dietary study of British boys (Table 17).

The average calorie intakes gradually increase with age, while the calorie intake per kg. body weight decreases with age. The calorie intake per cm. height was greatest at about adolescence and the intake per sq. m. of body surface did not vary consistently with age. The percentage of total calories derived from proteins, fat or carbohydrate seems to be independent of age, being an average 12 per cent. from protein, 23 per cent. from fat and 65 per cent. from carbohydrate.

The mean protein, calcium, phosphorus, iron, riboflavin and nicotinic acid intakes all increased with age but, except in the older age groups, the amount of animal protein was independent of age. Animal protein, in fact, contributed only 20 to 50 per cent. to the total protein in the diets. The average calcium intake per unit weight or per unit height and the thiamine and ascorbic acid intakes were all maximum at 16 years.

The phosphorus intakes are, at all ages, greater than those for British boys and this is no doubt due to the large cereal intakes of the Ceylonese boys. The Ca/P ratio in the food is between 0·08 to 0·20. These are very low values but it is not possible to estimate from the available experimental data what the retained Ca/P ratios were.

The consumption of some foodstuffs was independent of age, e.g. bread, butter, eggs, fish, fruits, nuts, green vegetables, pulses, sugar, preserves and sweets. These foods are treated either as luxuries or as minor contributions to the main meal. Other foodstuffs were eaten in increasing quantities from the age of 8 years onwards, e.g. milk, meat and vegetable fruits while the consumption of some foods only increased after the onset of adolescence, e.g. rice, roots and tubers (Table 18).

TABLE 16

Mean Chemical Composition of Daily Diets of Ceylon Tamil Boys.

Age in Years	Calories	Protein	Fat	Carbo-hydrate	Calcium	Iron	Phos-phorus	VITAMINS				
								A i.u.	Aneurin m.g.	Ribo-flavin mg.	Nicotinic Acid mg.	Ascorbic Acid mg.
8	966	33·1	14·9	180·2	143·4	4·8	1758·7	281	0·343	0·490	3·355	37·8
9	1039	31·5	14·9	196·5	152·9	7·2	1893·6	226	0·444	0·612	2·899	42·5
10	1128	33·0	27·2	184·0	100·1	10·1	1588·4	547	0·415	0·011	3·390	47·6
11	1416	48·8	37·4	224·3	291·9	15·2	2087·9	1183	0·597	0·766	3·906	54·3
12	1287	33·4	40·7	202·3	252·5	11·5	1455·4	894	0·460	0·660	3·540	55·8
13	1401	36·7	46·7	216·4	259·0	7·0	2071·6	689	0·461	0·626	5·098	43·0
14	1628	52·9	58·1	232·2	424·0	21·0	2172·6	283	0·781	1·380	6·146	71·1
15	1573	57·0	59·9	241·0	334·7	10·4	2415·6	1042	0·688	0·777	4·345	85·1
16	1699	51·1	44·1	282·2	315·6	17·1	2952·4	1074	0·770	1·425	5·944	92·0
17	1872	55·9	47·5	322·9	351·7	16·6	3039·5	902	0·635	1·822	5·626	71·6
18	2317	84·2	69·3	341·9	404·2	23·5	3467·6	1081	1·027	2·722	12·584	77·7
19	1851	61·5	46·8	297·7	403·7	29·8	2937·9	1613	0·952	2·263	8·781	61·3

TABLE 17

The Mean Chemical Composition of the Diets of British Boys (after Widdowson, 1947).

Age in Years	Calories	Protein g.	Fat g.	Carbo-hydrate g.	Calcium mg.	Iron mg.	Phos-phorus mg.	VITAMINS		
								A. i.u.	Thiamine mg.	Ascorbic Acid mg.
8	2170	60	82	283	740	11·4	1060	4600	0·71	52·4
9	2443	68	97	308	880	12·5	1240	4020	0·90	63·4
10	2501	73	94	315	840	12·7	1220	3990	0·80	55·4
11	2521	72	98	320	890	13·3	1260	3810	0·82	55·1
12	2630	76	103	331	690	13·6	1200	4300	0·95	53·4
13	2756	79	104	357	790	13·6	1250	4480	0·94	61·5
14	3065	89	116	396	760	17·5	1410	6150	1·01	46·0
15	3440	100	137	429	870	18·5	1560	6460	1·09	58·4
16	3105	94	123	384	790	18·0	1480	5880	1·13	53·5
17	3223	95	131	395	850	17·9	1500	4050	1·09	62·4
18	3427	97	137	402	850	18·0	1500	4630	1·03	50·6

TABLE 18

Average Consumption of Foodstuffs by Ceylon Tamil Boys. (oz. per week).

Age in Years	CEREALS		DAIRY PRODUCTS			FLESH FOODS			FRUITS AND VEGETABLES							
	Rice	Bread	Milk	Butter Curds and Ghee	Eggs	Meat	Fresh Fruit	Dry Fruit	Fruits	Nuts	Roots and Tubers	Pulses	Green Vegetables	Vegetable Fruits	Sugar	Preserves	Sweets
8	35·1	19·5	1·35	—	—	3·19	11·4	0·75	1·0	4·33	—	—	—	15·4	4·25	0·25	0·25
9	37·1	17·8	0·21	—	—	1·17	12·1	0·42	0·33	3·97	0·33	0·06	—	6·9	8·25	0·17	0·08
10	28·9	18·2	1·94	0·33	0·73	5·39	7·3	0·35	0·62	9·06	1·43	0·39	—	7·4	8·86	0·63	0·08
11	36·3	15·8	2·63	0·82	—	5·34	17·5	0·40	3·05	7·66	1·35	2·22	0·20	21·0	8·36	2·30	0·13
12	31·4	11·1	2·68	1·20	0·68	3·72	3·5	0·15	2·00	8·55	0·45	1·29	2·28	21·1	6·60	0·93	0·58
13	42·0	6·4	7·35	1·28	0·99	3·21	11·0	—	4·15	6·99	1·50	1·39	1·40	19·5	5·41	0·31	0·43
14	38·4	7·6	5·01	0·08	1·65	7·54	9·6	0·11	2·32	8·39	5·17	3·00	1·36	37·6	3·60	0·05	0·42
15	44·6	11·8	9·90	4·84	2·25	3·56	11·3	—	3·88	9·73	3·40	1·50	6·21	33·7	5·39	0·61	0·09
16	56·7	14·7	6·18	0·93	1·28	7·51	5·4	—	4·22	4·57	5·55	2·05	3·34	39·4	3·25	0·26	0·50
17	61·1	19·7	5·39	0·20	0·88	12·18	7·4	0·05	3·94	9·26	3·18	1·74	4·32	33·0	7·16	0·63	0·80
18	63·1	34·8	9·69	0·56	0·72	31·98	20·8	—	2·30	9·79	3·07	1·30	3·46	46·2	4·78	0·53	0·92
19	55·3	13·7	16·01	1·81	1·03	16·2	8·8	0·5	4·18	10·03	4·62	1·95	2·70	33·4	6·36	0·65	0·25

Compared with British boys, these Ceylonese boys ate more cereals, fish, nuts, vegetable fruits and pulses but less bread, milk and other dairy products, meat, fruits, root vegetables, green vegetables, sugar, preserves and sweets.

In general, the average chemical composition and calorie value of the diets of the Ceylonese present figures which are much smaller than any previously reported. These boys came from middle-class Tamil homes and a routine clinical examination classed them all as medically fit. More refined tests, (e.g. of dark-adaptation, blood plasma levels of the vitamins, urine excretion or saturation tests, etc.) may have revealed widespread deficiencies, but it was not possible to do such tests in a survey of this nature. Even allowing for the fact that sub-clinical deficiency states may have existed, it is still remarkable that such low calculated, average intakes should only have produced sub-clinical deficiencies.

The noted calorie intakes are only about a half of those reported by Widdowson for British boys. The Ceylonese were, of course, much smaller in height and weight than the British boys, but the calorie intakes per unit of height and weight were still much less than those of the British. The Ceylon boys would, no doubt, have been classed as underweight by British standards but they are typical of middle-class Ceylon Tamil boys.

It is evident that growth and development of the small-bodied Ceylon Tamil boys does occur on food intakes which are considerably less than those envisaged or reported for Western people. Several other observations suggest that our present figures may be of the right order of magnitude. The total available food in Ceylon is such that, were it to be distributed throughout the population according to consumption man-values, then each adult would receive only 9 oz. of rice per day. These figures approximate to those noted for our higher age groups of boys. The poorer sections of the population eat less than the theoretical amount available to them; the boys of 18 years were eating much more. It is possible, however, that the low intakes, reported here, may have been due to the limitation of available supplies in Ceylon. This seems unlikely since there is no real rationing in Ceylon; a certain minimum supply of rice is guaranteed to each person but the limitation of food supplies, by raising food prices to some extent, is noticed more by the poor than by the middle-class people.

Another possibility is that the table of food values, used in our calculations, may not apply to Ceylonese foods. We have already discussed this and we are undertaking analyses to check many of the values used. So far, these analyses do not indicate that there can be large errors of the magnitude to be expected from the differences between our figures and those for Western children.

We are left, therefore, with the further possibility, suggested by Nichols and Nimalasuriya (1939) for the low calcium intakes of the Ceylonese, that a process of racial adaptation may be involved. This really means that the metabolism of the Ceylonese is so efficient that they can grow and maintain health on much smaller intakes of calories, protein, mineral salts and vitamins than Western people. Such a hypothesis would be difficult to prove.

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APPENDIX

Specimen Forms used during Nutrition Survey of Ceylonese Communities

Community Survey

1. History of Community :—
2. Genealogies of Inhabitants :—
3. Family Structure :—
4. System of Land Tenure :—
5. Standards of Living :—
6. Methods of Production :—
7. Labour Supply :—
8. Incentives to Produce Food :—
9. Incentives to Engage in Wage Labour :—
10. Methods of distribution and exchange :—
11. Consumption of Food :—
12. Fluctuations in Food Intake at various times of year :—
13. Food customs, prejudices, taboos or religious customs :—
14. Native theories of Cultivation :—
15. Principles of Soil Selection :—
16. Principles of alternation of crops :—
17. Methods of Preparation of foods and time spent on preparation :—

Family Survey:— *Date:*

Name of Family :

Address :—

Names of Family: *Sex:* *Age:*

Family Medical History (1) Illnesses
(2) Deaths
(3) Miscarriages
(4) Stillbirths

Race Caste Occupation

Income Condition of house
Cost of house
Cost of food
Foods bought Cost of clothes
Other expenditure

Foods produced

Time spent on preparing food

Household management

Foods Consumed

Meal	*Food*	*Quantity*	*Number eating*	*How prepared*

Clinical Examination

Body Measurements	Height	Weight
Limb Circumferences	Arm	Forearm
	Thigh	Leg
Chest	Circumference	
	Breadth	
	Width	
	Depth	
Diameters	Biacromial	
	Bi iliac	
	Bi zygomatic	
Leg Length	Arm Length	Grip
Previous Illnesses		
Present Complaints		
Condition on Examination		
General appearance		
Skin		
Mouth	Tongue	Gums
Teeth—Mottling	Caries	Missing
Nasopharynx		
Eyes	Slit Lamp	Dark Adaptation
Limbs—Oedema	Muscle tone	
Heart	Blood Pressure	Pulse rate
Chest		
Abdomen		
Nervous System :—		
Posture	—flat feet	knock knees
	dorsal median furrow	
	lordsis	scoliosis
Bowels		
Vitality		