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An Investigation of the Daily Intakes of Food of Individual Boys at a Boarding School in Uganda

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The original purpose of the investigation was to measure the amount of food eaten by boys in the school, which was a boarding school, at a time when an unpopular diet had to be given because of high prices and shortages of better-liked foods. It was the best the school authorities could devise, but they had doubts of its value, and whether the boys were eating enough. The food eaten daily by thirty boys was therefore measured for 1 week. In the following term it proved possible to re-introduce better-liked foods, and the intakes of the thirty boys were measured again. The school food was not very ample so, to test its adequacy, nineteen of the boys were allowed to eat as much of it as they wanted for a further week during which their intakes were measured for the third time.

EXPERIMENTAL

Background of the investigation

Details of the school. The school is in the province of Buganda about 11 miles from Kampala. A large proportion of its pupils are children of chiefs or other prominent and prosperous members of the community; 85% are Baganda, an autochthonous Bantu tribe. The school fees are high by local standards but they defray only a fraction of the cost of the school; the rest is paid by a Uganda Government grant.

The school is run on the lines of an English public school; the headmaster is a European, and the staff of the secondary school, where all subjects are taught in English, is partly European. There is a separate primary school with an all-African staff. Girls are admitted to both schools, but form only 17% of the secondary school and 33% of the primary school. The kitchen, which supplies the primary school as well, is adjacent to the secondary-school dining room.

Kitchen and feeding arrangements. Some years ago the building of a new kitchen was begun, but for lack of money has never been completed. The partly finished walls, covered with a corrugated metal roof, shelter the cooking range, a series of low brick walls enclosing spaces in which wood is burnt. The spaces are covered with iron slabs with holes for the cooking pots, which are of iron and of two sizes, holding either 18 or 24 gal. The water for cooking is obtained from a single tap outside the kitchen and is heated in two large pots permanently sunk into brick stoves. In some of the unroofed rooms of the unfinished kitchen, and in an outhouse, vegetables are cleaned, and nuts are pounded with heavy wooden pestles in narrow wooden vessels.

A small amount of food is stored in two sheds which are kept locked; one of them serves also as an office for the caterer. The sheds are the only parts of the kitchen quarters that are well protected from the weather. On rainy days the firewood is usually wet, and meals are often late in consequence.

For many years an African caterer has bought the food and he supervises its cooking and distribution. Most of it has to be bought in Kampala where it is dearer than in the country but, except for some vegetables, it is impossible to buy food locally in sufficient quantities. Storage of food is limited by lack of accommodation and by the poor keeping qualities of the staple foods in a tropical climate.

The cooking and distribution of food. In Buganda, as in many other parts of Africa, a meal nearly always consists of a boiled or steamed, starchy staple accompanied by a sauce made of nuts and beans, meat, fish, or a mixture of vegetables. The two main meals served in the school each day were of that type; at the third meal, breakfast, porridge made with dried skim milk was served with tea containing milk and sugar (see Table 1).

The cooking of the food was very simple. Plantains and sweet potatoes were tied up in cloths and steamed in the large pots on a bed of banana leaves. The vegetables for the sauces were fried in small amounts of fat and added to the main ingredients which had previously been boiled soft in water. The maize-meal porridge was made with water, and the sugar and dried milk were added towards the end of cooking. The food for the two main meals was always cooked in the largest pots, and was stirred with heavy wooden sticks. The head cook served out the food into smaller aluminium pots which were taken into the dining rooms. There was nearly always more food per head in the secondary school dining room than in the two other dining rooms, and serving pots for the secondary school were usually filled a second time.

The school food. As far as possible the school had always attempted to supply the kind of food habitually eaten by the Baganda. The green plantain (*Musa balbisiana*) locally known as matoke, is the most popular staple. When that is not available, sweet

potatoes, *lumonde* (*Ipomoea batatas*), or rice may be eaten, and wheat-flour bread is becoming increasingly well liked. But rice and bread are expensive and the poorer people often have to fall back on cassava and maize flour. There is, however, very little knowledge of how to cook maize. It is usual to make the flour with water into a tasteless stiff porridge called *posho*, which is eaten widely in Kenya and in some parts of Uganda, but is despised by the Baganda, and there were always violent objections when it appeared in the school diet; a *posho* made with wheat was, however, more acceptable. Maize meal, made into a thinner, sweet porridge with dried milk and plenty of sugar, was normally well accepted in the school, though it was unpopular at times, which was hardly a cause for wonder, because most of the maize meal sold in Kampala is coarsely ground and is often bitter and musty. Recently, it has been possible to obtain a finer meal, made from well-dried grain, properly kept.

Matoke (green plantain) is uneconomical and comparatively expensive at any time, and from 50 to 60% of the bulk is lost in preparation; nevertheless, it was served as often as possible. The alternative, *lumonde* (sweet potato), is equally wasteful, but far cheaper. Rice was served occasionally. At the time of the investigation the money allotted for catering was 1 East African shilling (containing 100 cents and equivalent to 1 English shilling) for each boy daily. Out of that sum the wages of the twelve cooks had to be paid, so that only 91 cents were available for food. In the two first terms of 1953 meat, which was the most expensive item, was served only twice a week but, in spite of that, the food allowance was much overspent owing to a sudden and unusual increase in food prices after poor crops caused by a prolonged drought. The difficulties were acute, and the school's domestic science mistress was asked to re-plan the diet for the third term of 1953 so as to ensure the maximum food value without further overexpenditure. Supplies of green plantains had become unreliable as well as expensive so they were cut out altogether and sweet potatoes were only served occasionally as an addition to a main meal. Instead of the usual staples a steamed wheat-flour cake, made from standard flour of about 85% extraction, was offered with sauce at the evening meals and maize meal formed the basis of the midday meals. In the next term, after a satisfactory rainy season, it became possible to revert to a more popular diet but, because of the expense, some of the skim milk was omitted, and the amount of animal protein was unfortunately reduced still further because the boys refused to eat tinned meat which was offered instead of the usual fresh meat. Details of the two diets are given in Tables 1 and 2.

The values in Table 1, which shows details of the food allotted by the school, are calculated as $\frac{1}{400}$ th of an average of the quantities cooked daily, 400 being approximately the total number of children, boys and girls together, in the school. They are somewhat less than the amounts laid down by the domestic science mistress because, in an attempt to be as economical as possible, the caterer had reduced the amounts since food was almost always left in the secondary-school dining room.

In the course of the investigation a large difference was revealed between the amount of food in theory supplied by the school and that eaten by the boys (see Table 6). About one-third of the total calories intended for the boys apparently did

Table I. Amounts and values of one portion* of food provided by the school during the investigation

Meal	No. of item	Food†	Weight (g)	Animal protein (g)	Total protein (g)	Fat (g)	Carbo-hydrate (g)	Calories (Cal.)	Cost in cents‡			
									Total	/100 Cal.	/g protein	
Period 1												
Breakfast	I ₁	{Maize porridge {Tea	350-380 300-350	4.9 1.6	7.4 1.6	0.6 —	51.7 25.9	230 104	8.9 4.5	— —	— —	
Morning break	II ₁	Tea	325-350	1.6	1.6	—	25.9	104	4.5	—	—	
Lunch	III ₁	{Milk porridge {Bread	900-1000 70-80	9.8 —	20.5 6.5	2.3 0.6	158.0 47.5	697 211	22.2 9.0	— —	— —	
		{Lunch posho {Nut and bean sauce	150-200 225-275	— —	6.8 19.6	1.5 20.1	71.0 30.2	308 382	5.6 14.0	— —	— —	
Afternoon break	V ₁	Tea	325-350	1.6	1.6	—	2.2	15	1.8	—	—	
Supper	VI ₁	{Wheat posho {Nut and bean sauce	130-150 225-275	— —	9.4 19.7	4.0 21.0	62.1 30.8	311 392	10.7 13.6	— —	— —	
		{Wheat posho {Bean sauce	130-150 425-475	— —	9.4 28.8	4.0 15.1	62.1 65.0	311 502	10.7 17.9	— —	— —	
		{Wheat posho {Meat sauce	130-150 150-175	— 15.6	9.4 18.7	4.0 15.0	62.1 21.4	311 296	10.7 39.0	— —	— —	
Whole-day combinations:												
A ₁	I ₁ , II ₁ , III ₁ , V ₁ , VI ₁	—	—	19.5	68.3	28.5	404.1	2064	74.7	3.6	1.1	
B ₁	I ₁ , II ₁ , IV ₁ , V ₁ , VII ₁	—	—	9.7	76.8	41.3	334.0	1953	67.9	3.5	0.9	
C ₁	I ₁ , II ₁ , III ₁ , V ₁ , VII ₁	—	—	25.3	67.3	22.5	394.7	1995	99.7	5.1	1.5	
Mean value for 1 day of weekly combination of: A ₁ (twice), B ₁ (three times), C ₁ (twice)												
—	—	—	—	16.1	71.7	32.3	371.4	1994	78.9	4.0	1.1	
Period 2												
Breakfast	I ₂	{Maize porridge {Tea	350-380 325-350	2.6 2.8	5.2 2.8	0.6 —	49.6 27.3	212 114	6.3 5.5	— —	— —	
Morning break	II ₂	Tea	325-350	2.8	2.8	—	27.3	114	5.5	—	—	
Lunch	III ₂	{Lumonde {Nut and bean sauce	650-750 225-275	— —	20.0 6.6 20.0	2.5 22.0	134.2 30.6	551 401	14.0 14.0	— —	— —	
		Tea	325-350	2.8	2.8	—	3.9	26	3.5	—	—	
Supper	V ₂	{Matoke or lumonde {Nut and bean sauce	375-425 225-275	— —	6.6 5.3 20.0	— 22.0	91.8 30.6	366 401	23.4 14.0	— —	— —	
		{Matoke or lumonde {Vegetable sauce	375-425 400-450	— —	5.3 0.8	— 7.4	91.8 3.8	366 87	23.4 11.2	— —	— —	
		{Matoke or lumonde {Meat sauce§	375-425 125-175	— 19.1	5.3 19.8	— 17.4	91.8 3.8	366 257	23.4 34.5	— —	— —	
Whole-day combinations:												
A ₂	I ₂ , II ₂ , III ₂ , IV ₂ , III ₂	—	—	11.0	66.8	49.6	437.7	2375	76.8	3.2	1.1	
B ₂	I ₂ , II ₂ , III ₂ , IV ₂ , V ₂	—	—	11.0	65.5	47.1	395.3	2192	86.2	3.9	1.3	
C ₂	I ₂ , II ₂ , III ₂ , IV ₂ , VI ₂	—	—	11.0	46.3	32.5	368.5	1872	73.4	3.9	1.6	
D ₂	I ₂ , II ₂ , III ₂ , IV ₂ , VII ₂	—	—	19.1	64.6	42.5	368.5	2006	106.7	5.3	1.6	
Mean value for 1 day of weekly combination of: A ₂ (three times), B ₂ (three times), C ₂ (once) A ₂ (three times), B ₂ (twice), D ₂ (twice)												
—	—	—	—	11.0	63.3	46.1	410.2	2220	80.3	3.6	1.3	
—	—	—	—	13.3	63.5	46.9	409.6	2213	88.0	4.0	1.4	

* For this table the portion has been taken as $\frac{1}{400}$ th of the total food cooked, there being 400 boys and girls in the school.

† For recipes see Table 2.

‡ See p. 232.

§ The vegetable sauce was served alone on one of the meat days because the boys refused to eat the tinned beef provided. After the first 2 weeks in the second term no meat was served at all as a punishment.

not reach them; the school food was being shared, officially or unofficially, by many other people, including the cooks and kitchen staff, and the servants of Europeans working at the school.

Table 2. *Recipes used at the school (quantities taken for 400 portions)*

Item	Ingredients	Weight as cooked		Item	Ingredients	Weight as cooked	
		Period 1 (kg)	Period 2 (kg)			Period 1 (kg)	Period 2 (kg)
Breakfast porridge	White maize flour	11.34	—	Bean sauce	Beans (dried)	45.35	—
	Yellow maize flour	—	11.34		Standard wheat flour	5.67	—
	Sugar	9.07	9.07		Fat	5.67	—
	Skim milk powder	5.67	3.06		Salt	1.81	—
Breakfast and break tea	Tea dust	0.46	0.46		Onions	5.44	—
	Sugar	9.07	9.77		Vegetables (as available)	5.89	—
	Skim milk powder	1.81	3.40	Meat sauce	Fresh meat	32.65	—
Afternoon tea	Tea dust	0.46	0.46		White maize flour	10.20	—
	Skim milk powder	1.81	3.40		Standard wheat flour	—	3.28
				Fat	5.67	3.17	
Lunch porridge	White maize flour	45.35	—		Salt	1.81	1.81
	Sugar	22.67	—		Onions	5.44	12.35
	Skim milk powder	11.34	—		Vegetables (mixed)	5.89	12.35
Lunch posho	White maize flour	22.67	—		Curry powder	—	0.23
	<i>Lumonde</i>	45.35	—	Steamed wheat cake	Standard wheat flour	34.90	—
Nut and bean sauce	Groundnuts	11.34	12.10		Baking powder	0.91	—
	Beans (dried)	22.67	22.80		Fat	0.91	—
	Fat	2.83	3.06	Salt	0.28	—	
	Salt	1.81	1.81				
	Onions	5.69	5.69				
	Tomatoes	6.80	—				
	Cabbage	—	6.30				

Extra food. The school has a tuck shop at which sugar, sweets and bread can be bought, and local vendors come to the school on most days with buns, sweets, nuts and fruit; fruit was, however, more usually picked from trees in the grounds of the school or from the private gardens of the European staff. Some items were brought or sent from home. The items constituting the extras are shown in Table 3.

Technique of the investigation

The boys who took part in the investigation were all volunteers aged from 9 to 20 years; twenty-four were in the primary school and eight in the secondary school. Younger children were not included as being unlikely to co-operate sufficiently. There was no other selection. The boys investigated were almost exactly one-tenth of the total number of boys in the school and appeared to represent a good random sample; their weights are shown in Fig. 1 against the curve of weight for age for all the 303 boys in the school. There was stormy political feeling in the secondary school which made it not possible to include as many boys above the age of 14 years as was desirable.

Intake was measured for 7 consecutive days, and not more than eight boys were investigated at any one time. Two European members of the Medical Research Council Group for Research in Infantile Malnutrition stayed at the school during the

Table 3. Contribution of different items to total calories from extras

Item	Period 1		Period 2		Period 3	
	No. of boys	Proportion of total extra calories (%)	No. of boys	Proportion of total extra calories (%)	No. of boys	Proportion of total extra calories (%)
Sugar	30	43	32	53	20	66
Bread	24	24	24	21	16	10
Buns	16	10	22	13	10	6
Nuts	20	9	7	2	—	—
Biscuits	6	<1	11	2	5	3
Plain cake	5	<1	1	<1	—	—
Butter	4	<1	5	<1	2	<1
Jam	5	<1	4	<1	1	<1
Boiled egg	—	—	1	<1	—	—
Curry powder	—	—	1	<1	—	—
Condensed milk	2	<1	—	—	—	—
Grasshoppers	2	<1	—	—	—	—
Boiled beans	7	<1	—	—	—	—
Boiled maize	2	<1	—	—	2	<1
Boiled rice	2	<1	—	—	1	<1
Millet porridge	1	<1	—	—	—	—
Fruit squash	2	<1	3	<1	1	<1
Avocado pears	—	—	7	2	2	<1
Bananas	3	<1	2	<1	3	2
Grenadilloes	3	<1	—	—	—	—
Lemons	4	<1	—	—	—	—
Mangoes	4	<1	1	<1	—	—
Oranges	8	<1	1	<1	2	<1
Pawpaw	1	<1	—	—	—	—
Pincapple	1	<1	—	—	—	—
Boiled sweets	19	3	5	1	10	3
Toffees	2	<1	—	—	—	—

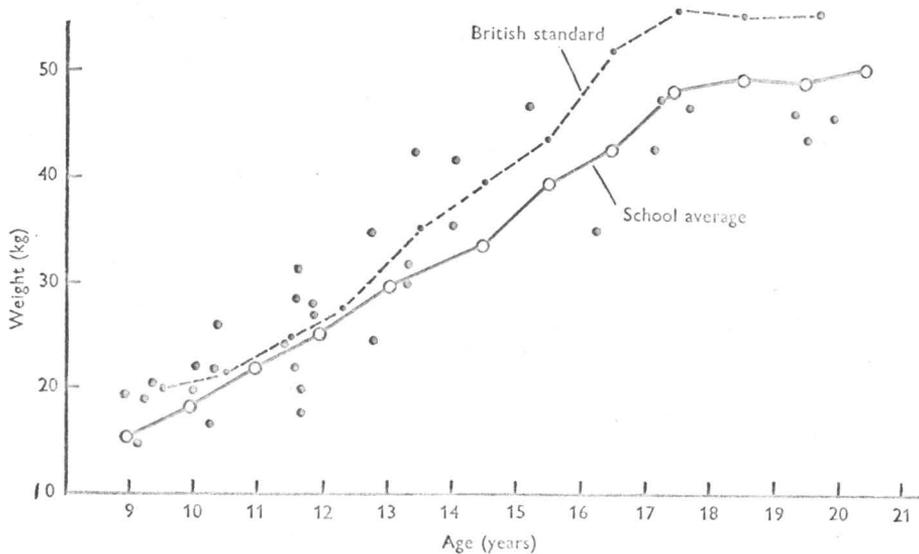


Fig. 1. Mean weights at the beginning of period 1 (shown as dots) of the thirty-two boys taking part in the investigation compared with the mean for all the boys in the school and with a British standard (Widdowson, 1947).

investigation. They were present at all the meals and weighed the food served out to each boy, and any food that might be left over, on a spring balance weighing up to 1 kg. Each boy had his own numbered plate and cup which he kept during his investigation period. Most of the extra items bought by the boys were weighed at meal times, especially in the two tea breaks; food eaten in the dormitories was weighed by a house prefect who was provided with a balance.

Records were made each day of the amounts of food put into the cooking pots. Weighed samples of the cooked food were dried on flat tins in the sun to obtain an estimate of the water content, which varied considerably from day to day. Sun drying was the most practical method as there was no electricity or gas at the school. The food values were calculated from tables of food composition (Platt, 1945; McCance & Widdowson, 1946; Chatfield, 1953), the factors 4.1, 9.3 and 3.75 being used for the calorie value of protein, fat and carbohydrate, respectively. It was recognized that the method of calculation might involve many errors, especially because the values used had been determined for foods grown elsewhere than in Uganda, but facilities for chemical analysis were not available at the time. For this reason no attempt was made to calculate the intake of minerals and vitamins.

In the period when the food intake was unrestricted, one of the observers served the boys of the investigation group out of separate pots which always contained an excess of food. It was unfortunate that because of the political situation mentioned earlier, no older boys could be included in this third investigation.

There were no data from African sources that could be used to provide standards of weight for age, or of calorie intake for age. For the purpose of comparison with the present results, the data collected by Widdowson (1947) on British children in 1937-9 have been used.

In the following account, the time when the unpopular diet was measured is referred to as period 1, and the other times when the more popular diet was given, first in the habitual way and afterwards in unlimited amount, as periods 2 and 3.

RESULTS

Total intakes. The mean daily intakes in the three periods are shown in Table 4. The amounts of animal protein, total protein, fat and carbohydrate, and the calorie values, are given with comparable figures from Widdowson (1947). In the children investigated by Widdowson, there was a well-marked change of intake with age, but in the African schoolchildren no such change could be demonstrated either in the intake of calories from all sources (Fig. 2) or in the intake from school food only (Fig. 3). The means obtained by combining the results for children of different ages are, therefore, valid whereas similar means from Widdowson's figures would have little significance.

The amount of carbohydrate eaten by the African boys was at least as great as the amount eaten by the British boys. The total protein was slightly lower than the figures for the British boys 9 years old, and the animal protein and fat were very much lower. The mean calorie intakes were therefore lower; the younger children took daily about 700 Cal., and the older children about 1500 Cal., less than the British boys.

When the change was made from the unpopular to the popular diet (periods 1 and 2), there was an increase in the intake from school food and a decrease from extras, but there was no increase in the total caloric intake; the small difference between the mean values of 1953 and 1889 Cal. was not statistically significant. The mean amounts of

Table 4. Mean total daily intakes by the schoolboys in periods 1-3

Period	No. of boys	Animal protein (g)		Total protein (g)		Fat (g)		Carbohydrate (g)		Calories (Cal.)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
1 ^{not} 1953	30	15.5	8.6-23.4	59.9	40.7-76.9	26.8	12.5-45.9	389.5	286.0-504.4	1953	1459-2345
2 ^{extra} 1953	32†	8.7*	6.8-11.1	45.5*	33.4-57.5	28.0	21.5-36.3	383.7	323.9-488.0	1889	1619-2377
3 ^{extra} 1953	19‡	10.1	7.1-12.8	55.6*	41.9-66.6	36.3*	24.1-53.2	401.9	332.3-498.6	2073	1748-2528
British children:											
9 years old		43		68		97		308		2443	
18 years old		60		97		137		402		3427	

(Widdowson, 1947)

* These values are significantly different ($P < 0.05$), by statistical analysis, from the figures immediately above them in the same column.

† Two extra boys, in addition to the original thirty, volunteered to have their diets measured in period 2. They did not affect the general means.

‡ The mean intakes in period 2 of the nineteen children investigated in period 3 were in all respects the same as the general means in period 2.

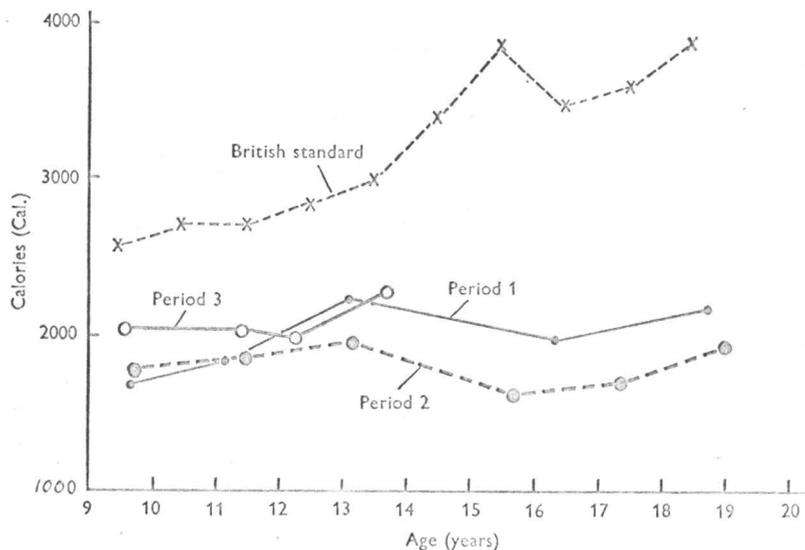


Fig. 2. Mean daily total caloric intakes in the three periods of the investigation, compared with intakes of British children of the same age (Widdowson, 1947).

total protein and animal protein fell, but the mean amounts of fat and carbohydrate did not alter. The fall in protein was only in part caused by the change of staple foods; as already explained (p. 232) there were other changes that affected the amount of animal protein.

When the popular diet was offered in unlimited quantities (period 3), the mean total caloric intake increased by 184 Cal. There was a mean increase of 275 Cal. due to school food, and extras decreased by 91 Cal. The 275 Cal. were accounted for by mean increases of 11.3 g total protein, 10.1 g fat and 35.6 g carbohydrate. These figures show that the increase could not have been chiefly due to the eating of larger amounts of the staples, which contained very little protein and fat. Analyses showed, in fact, that the item of food of which the consumption increased most was sauce, which increased 27% by weight; *matoke*, *lumonde* and breakfast porridge increased by much less, only 12%. Tea increased by 7%.

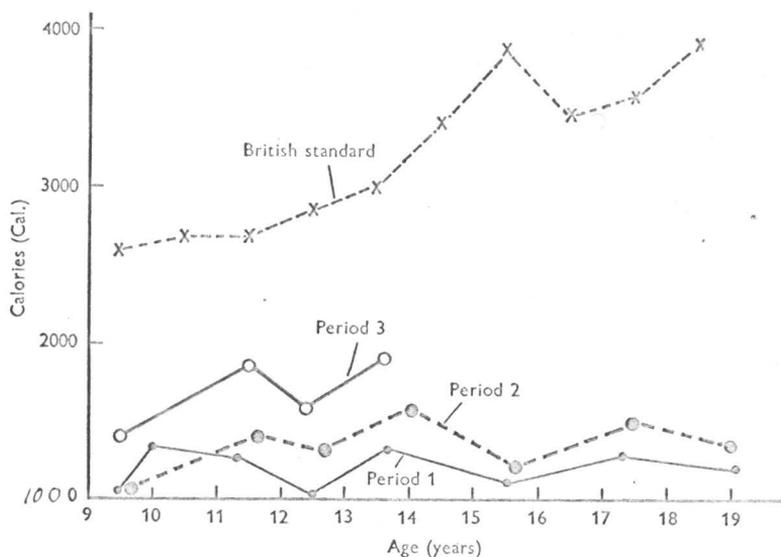


Fig. 3. Mean daily caloric intakes derived from school food in the three periods of the investigation, compared with intakes of British children of the same age (Widdowson, 1947).

Proportions of protein, fat and carbohydrate. Table 5 shows the percentages of the total calories that were derived from protein, fat and carbohydrate, and comparable British values. In the school diets, the contributions of animal protein and fat were very small. The percentage contribution of total protein was greatest in the unpopular diet of period 1, and then slightly exceeded the British percentage; it was a little lower

Table 5. *Proportion of total calories derived by the schoolboys from protein, fat and carbohydrate in periods 1-3*

Period	Proportion of total calories derived from			
	Animal protein (%)	Total protein (%)	Fat (%)	Carbohydrate (%)
1	3.3	12.5	12.7	74.8
2	1.9	9.9	13.7	76.3
3	2.0	11.0	16.2	72.8
	British-boys (Widdowson, 1947)			
	7.5	11.9	36.4	51.3

in the other periods. Carbohydrate, which was responsible for only half of the British boys' calories, was responsible for three-quarters of the African total in all three periods.

Intake from school food and from extras. The average intakes from school food are shown in Table 6. They were, as already mentioned (p. 232), much lower than the amounts theoretically allocated by the school authorities. The calories obtained from the school diet were supplemented by the extras bought by the boys; as shown in the lower part of the table, 569 Cal. were obtained from extras in period 1, and 415 and 324 in periods 2 and 3, respectively. The extras were obviously an important part of the diet (see Table 7).

Table 6. Mean daily amounts of school food allocated by the school authorities, amounts actually eaten, and amounts of extras

Class of food	Period	No. of boys	Animal protein (g)		Total protein (g)		Fat (g)		Carbohydrate (g)		Calories (Cal.)	
			Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Amount allocated by school	1	—	19.8	—	74.4	—	32.5	—	391.7	—	2082	—
	2 and 3	—	13.3	—	62.4	—	46.9	—	406.2	—	2213	—
Intake from school food	1	30	15.2	8.6-25.9	49.5	35.4-69.7	19.4	9.4-37.9	267.5	160.9-372.4	1384	975-1735
	2	32	8.7	6.0-11.1	40.9	28.5-50.3	24.1	13.0-34.4	288.8	172.3-344.1	1474	1000-1874
	3	19	10.1	7.1-12.8	52.2	34.2-64.3	34.2	28.6-42.3	324.4	247.5-388.4	1749	1275-2235
Intake from extras	1	30	0.3	0.0-0.3	10.4	0.2-19.5	7.4	0.2-12.5	122.0	31.1-220.7	569	148-1192
	2	32	—	—	4.6	0.0-11.2	3.9	0.2-8.2	94.9	14.3-163.5	415	169-718
	3	19	—	—	3.4	0.4-7.7	2.1	0.1-6.9	77.5	34.8-138.6	324	173-613

As might be expected, the contribution of extras was greatest in period 1, when the school diet was so unpopular. In that period, and also in periods 2 and 3, the chief extra was sugar, and the amount taken did not change much from period to period. One-third, one-fourth and one-fifth of the carbohydrates in periods 1, 2 and 3, respectively, were extras, and sugar was mainly responsible. Every child was expected to provide his own sugar for the afternoon tea, which was served unsweetened, but most of the boys brought sugar to every other meal at which tea was served; it was quite common to add from 30 to 50 g sugar to a cup that already contained 20 g, and frequently sugar was sprinkled on the sweet breakfast porridge. There appeared to be no limit to the acceptable degree of sweetness. The mean amount of extra sugar eaten in a week was about 420 g, but one child had 1300 g and another, a small boy at the end of term, had only 20 g in the week.

In period 1 the consumption of sustaining foods, such as bread, buns and nuts, was greater than in the other periods, and in the secondary school the much disliked wheat cake was replaced occasionally with boiled rice or millet porridge, when a cook could be persuaded to prepare them. The variety of extras also was greatest in period 1; it was least in period 3, partly because that period was near the end of term, when most of the term's pocket money had been spent. The amounts of money spent on extras during the investigation varied from 14 East African cents (the equivalent of about 1 $\frac{3}{4}$ d.) to 5.35 East African shillings (about 5s. 4d.) in a week, and could not be related

to the age of the child, or to any other factor. Details of the extras, including the calorie contribution of each item, are given in Table 3.

Intake in relation to body-weight. Widdowson (1947) found that individual variation was so great that it was impossible to predict the calorie intake of an individual child from its age, weight, height or surface area. The number of children in the present investigation was so small that means for the intakes of yearly age groups could have little meaning; the ranges (see Table 4) were, however, much less than those reported by Widdowson, who found that at all ages the maximum was about twice the minimum.

Table 7. *Proportion of total intakes of the schoolboys supplied by extras*

Period	No. of boys	Animal protein (%)	Total protein (%)	Fat (%)	Carbohydrate (%)	Calories (%)
1	30	2	17	28	31	29
2	32	0	10	14	25	22
3	19	0	6	6	19	16

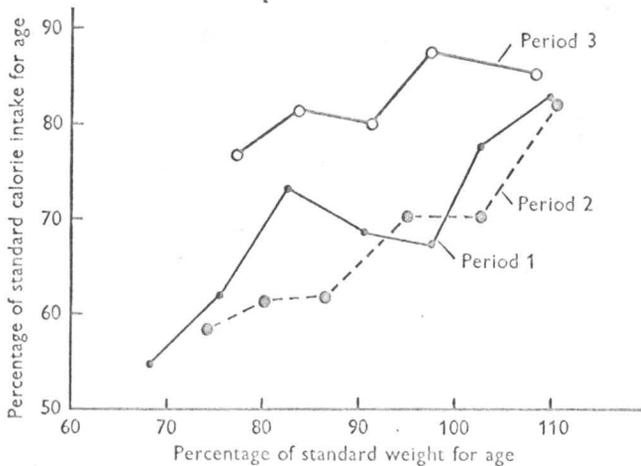


Fig. 4. Mean percentage of standard weight for age for the boys in the three periods of investigation plotted against mean percentage of standard calorie intake for age. The standards are those of Widdowson (1947) for British children.

The narrowness of the range in the African children is puzzling; it cannot be accounted for entirely by the failure of the school to provide an item of diet that could be used for filling-up, or by any restrictions in the amount of extras, and it seemed that very large appetites either did not occur, or could not be satisfied. The former alternative must seem strange to anyone with experience of European children, but it may not be so strange in a community in which the staple foods are always bulky in relation to their calorie value.

In one respect the African children showed a fair degree of consistency. If they were divided according to their degree of approach to the British standard for weight, those who were nearest to that standard also had calorie intakes that were nearest to the intakes of British children (Fig. 4). In other words, the children who were well

grown for their age had the best appetites or at least got the most food. The conclusion may seem reasonable, but it was not necessarily self-evident. The calorie intakes of children who were small for their age, under 90% of the weight of British children of the same age, were examined separately from those of the children who were large for their age, in each of the three trial periods. In period 2 most of the children who were small for their age had a lower calorie intake than they had in period 1, and most of the children who were large for their age had about the same intake as in period 1. The differences in the mean intakes of the two groups in both periods were found to be significant when analysed statistically. In period 3 the largest children did not have greater average intakes than the smallest, and did not increase their intakes more.

DISCUSSION

One of the most remarkable features of the investigation was the discovery of the low calorie intakes of the children. It was originally thought that the main factor limiting intake in period 1 was the unpopularity of the food offered by the school. The intakes in period 2, when the food was more popular, were much lower than was expected, the consumption of school food being only slightly greater than in period 1. In both periods food was hardly ever left over, at least in the dining room of the primary school, and it might be argued that the limiting factor in period 2 was the small amount of food that was offered. But even in period 3, where there was no limit to the food available, all the intakes were still below 90% of those of British boys of the same ages; for some reason the boys failed to eat enough of the popular diet to provide them with a large calorie intake. It must be remembered, however, that the boys investigated in period 3 were all under 15 years of age; older and larger boys might have achieved greater intakes.

There were no clinical signs of undernutrition in the children who took part in the investigation or in any other children at the school, which has been under more or less constant supervision for over 3 years. The general weight curve of boys at the school is known; it is shown in Fig. 1, and is clearly below that of British children. The curve for Africans cannot with certainty be taken as evidence of a state of malnutrition; it may merely correspond to a pattern of growth slower than that of British children, a suggestion that is reinforced by some other work (as yet unpublished) that has shown a tendency for African children to grow in height for some years after British children have stopped.

The weights of the children investigated were fairly representative, in relation to age, of weights in general at the school (Fig. 1); especially at the lower ages, they tended to be above the mean rather than below it. The children's weights do not prove that their nutritional status was good but, if it was bad, the failure of their calorie intake to increase greatly when they were offered unlimited amounts of the food they liked best, was all the more remarkable; undernourished children can be expected to have large appetites, except in the few specific diseases of malnutrition in which anorexia is a feature.

The important question seems to be whether the children investigated suffered from

the consequences of a deficient diet. The school diet in periods 2 and 3 resembled fairly closely that eaten in most Baganda homes, but it has been established, by routine weighings, that the children usually gain more weight at home in their holidays than they do during term time. A similar phenomenon has been observed in children at English public schools (Widdowson & McCance, 1944), and is probably explained, especially in the African children, by the greater amount of activity that is enforced at school. In the wealthiest homes, better food may add to the effects of inactivity. The difference between the diets of the moderately well-off and the rich seems to reside, not in the quantities of plantains and sweet potatoes that are eaten, but in the quantity and quality of the sauces. The school diet was low in fat. It is known that when the Baganda can afford to do so, they eat considerably more fat than was given to the children, and eat it mostly in their sauces. If the sauces are very rich, African children may achieve calorie intakes near those of British children. The chief reason for the small calorie intakes may have been the limitation enforced by the bulkiness of the diet, and it would have been interesting to offer a supplement of fat that would yield more calories without increasing the size of the helpings. It is possible that a larger calorie intake would stimulate faster growth, but that could be settled only by a carefully controlled experiment in which food of the best quality attainable, within the limits of taste and capacity, was given for a period of 2 years or more. The experiment would be valuable; at present very little is known for certain about the growth potentialities of Africans. It is popularly believed that their growth is limited by inadequate feeding, but as yet there is little evidence for that belief.

There is no agreement about ideal rates of growth, and ideal final stature, but it seems that if the results of the present investigation are widely applicable, the young child must possess an enormous appetite, and be so fortunate as to obtain the finest sauces, if he is to grow to the maximum of his capabilities. On the other hand, the lower calorie intake that seems to be his more usual lot may, for all that can be said with certainty at the moment, be entirely adequate. Comparisons with British children may be misleading. The needs of European and African children may differ in many ways. The higher African temperature may reduce the necessary calorie intake by more than 5% (Food and Agriculture Organization of the United Nations: Committee on Calorie Requirements, 1950), although the validity of making such a correction for children might be questioned, and there are undoubtedly many other unknown factors that should be taken into consideration.

The protein intakes of the African children were low compared with those of British children. The total intake of protein on the unlimited diet of period 3 was under 60 g daily, and the animal protein in period 1, in which it was highest, was only 15 g daily. It is known, however, that adults may be physically active when living on diets containing less than 60 g total protein, and that their blood chemistry is entirely normal (Mirone, 1954), and there is no known necessity for a high proportion of animal protein in a diet that has enough total protein. The proportion of the total calories derived from protein in the diets of the African children was almost exactly the same as that in those of the British children investigated by Widdowson (1947).

It is impossible to say whether the addition of protein to the African diet would be

an advantage, and that is another matter for speculation until it has been settled by the long overdue experiment. Nothing is known about the absorption and utilization of protein in these children.

One other feature that seems worthy of comment was the children's consumption of sugar. The amount of sugar taken as an extra, and therefore eaten uncooked, has already been mentioned; a further 300 g was supplied by the school, making a weekly total of 720 g. British children aged about 9-11 years took as much (Widdowson, 1947), but only about 250 g of it actually as sugar, in tea, or sprinkled on breakfast cereals, puddings and stewed fruit; the African children took about 520 g of their sugar uncooked, chiefly in tea. It would be of interest to find out whether uncooked sugar taken in this way is deleterious to the teeth. At one time the school had provided sugar-cane but it was one of the earliest casualties of the drive for economy.

Finally, it is necessary to consider to what extent the nutrition of the school described is representative of that in schools in Uganda. No statistical data are available, but information obtained from various sources makes it obvious that the school is one of the better fed. There is no evidence that the children at any of the schools are undernourished, and it must be emphasized that until it has been shown definitely, in controlled feeding trials, that dietary supplements are advantageous, any scheme for increasing or improving the diet will be without scientific foundation or justification.

SUMMARY

1. Individual food intakes of boys from 9 to 20 years old, chiefly Baganda, were measured at a boarding school in Uganda, for three periods, (1) when the school diet was unpopular and limited in amount (thirty boys), (2) when the school diet was popular but still limited (thirty-two boys), and (3) when the popular school diet was offered in an unlimited amount (nineteen boys).

2. All the food intakes were below 90% of those of British boys of the same ages, even when unlimited school food was offered. The intakes bore no relation to age, but well-grown children at any age had better appetites than those that were less well grown.

3. The intake did not increase when unlimited school food was offered, possibly because the bulkiness of the diet made larger amounts unacceptable.

4. All the boys supplemented the school food with extras which accounted for one-third, one-fourth and one-fifth of the total intakes in periods 1-3, respectively. The most important extra item was sugar which was taken chiefly in tea in large quantities.

5. Although some of the boys were underweight by British standards, no definite signs of undernutrition were seen.

6. The implications of the findings are discussed in relation to the customary diet of the boys, and it is stressed that the supplementation of African diets, however justifiable it may be in theory, needs first the foundation of exact experiment.

We wish to thank Miss M. G. Robinson and Miss R. Hecht for their valuable help in collecting the information. They also, with Mr P. P. M. Jones, made many of the calculations. The work would not have been possible without the friendly co-operation

of the Headmaster of the school, and we are most grateful to him. He and others of his staff very kindly provided accommodation for the members of the Medical Research Council Group who lived at the school during the investigation. The Domestic Science Mistress and the Caterer were at all times willing to give information about the school food, and to help in many other ways. Finally, we wish to thank most warmly the boys who took part in the investigation, although it caused considerable disruption of their routine.

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Metabolism of Carotene and Vitamin A Given by Mouth or Vein in Oily Solution or Aqueous Dispersion to Calves, Rabbits and Rats

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It is now generally accepted that in many species of the higher animals carotene taken by mouth is converted to vitamin A in the intestinal wall (see, for example, review by Kon & Thompson, 1951). There is both less agreement and less evidence on the value as vitamin A precursor of carotene given parenterally (cf. Church, MacVicar, Bieri, Baker & Pope, 1954). The observations of Tomarelli, Charney & Bernhart (1946) about the relation between the utilization of carotene introduced by injection and its state of dispersion offer an explanation of the divergence of findings. The careful work of Bieri & Sandman (1951) and Bieri & Pollard (1954) with rats, of Hentges, Grummer & Sorensen (1952) with pigs, of Church *et al.* (1954) with sheep, and of Bieri (1955) with chicks and rabbits, shows beyond reasonable doubt that these animals under suitable conditions convert into vitamin A carotene introduced directly into the body. In all these experiments carotene was dispersed in water-miscible surface-active agents. With the same technique Eaton, Matterson, Decker, Helmboldt & Jungherr (1951) found conversion in the calf, but Church *et al.* (1954) failed to do so.

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The object of the work now reported was to study the conversion to vitamin A of carotene in oily solution or aqueous dispersion, administered by mouth or injection to rats, rabbits and calves, and the fate of preformed vitamin A similarly administered to the same species.

EXPERIMENTAL

*Preparations of carotene and vitamin A**Carotene*

Crystalline carotene was obtained from the British Chlorophyll Co. Ltd. It contained some 90% β -carotene and 10% α -carotene.

Preparation of carotene for injection or feeding. The aqueous dispersions were made in two ways: (a) by using a 20% (v/v) solution in water of Tween 40 (polyoxyethylene-sorbitan monopalmitate, Atlas Powder Co., Wilmington, Delaware) essentially as described by Bieri & Pollard (1954), which will be referred to as Tween dispersions; and (b) by using colloidal dispersions prepared by the method of Drummond & MacWalter (1935) (cf. With, 1939). Oily solutions of carotene for use by mouth were prepared as described by Thompson, Ganguly & Kon (1949). Such oily solutions were given also as emulsions in water. The emulsions were prepared by putting through a homogenizer a mixture of 250 ml. of the oily solution, 5 ml. oleic acid, 3 g Na_2CO_3 and 750 ml. water.

Vitamin A

Crystalline vitamin A acetate was obtained from Roche Products Ltd, for use as such for feeding or injection, as described above for carotene.

Vitamin A alcohol was obtained from the acetate by saponification and chromatography, and prepared for feeding or injection as described above. All solutions were made up just before use. For some of the earlier experiments with calves, concentrates of fish-liver oil containing 30,000–100,000 i.u./g were used.

*Rats**Preparation and dosing of animals*

Rats partly depleted of vitamin A were prepared as described by Thompson *et al.* (1949). On one occasion normal adult stock-colony rats with large reserves of vitamin A were used.

Rats were anaesthetized with diethyl ether; the Tween dispersion of carotene or vitamin A, or carotene in oil, was injected with a no. 19 (26 s.w.g.) hypodermic needle into the tail vein or into the vena cava or vena porta exposed by a mid-line incision. For injection, the tail was immersed in warm water to dilate the vessels. In some instances anaesthesia was maintained for the whole experiment, but in most the rats were allowed to recover and were killed 5 min to 24 h later. When rats were to receive preparations by mouth they were force-fed by stomach tube, for which purpose 1 g diet was mixed with 1 ml. Tween dispersion and 3 ml. water, or 1 g diet mixed with 400 mg of the oily solution was mixed with 4 ml. water. At a suitable interval after dosing or injection, the rats were anaesthetized with diethyl ether, the chest was