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Malnutrition in African adults

4.* Intestinal absorption

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The absorption of foodstuffs from the alimentary canal seems to have received rather less attention than it deserves. No firm estimate can be made of the nutritive value of a diet unless it is known what proportion of the nutrients which it contains is actually absorbed and utilized. This was recognized by F.A.O.: Committee on Calorie Conversion Factors and Food Composition Tables (1947) set up to consider the 'energy-yielding components of food and computation of calorie values'. In its report, the Committee discusses many of the difficulties and discrepancies caused by our lack of knowledge, both of the absorption of foods and often of their true energy and nitrogen values.

On account of the great importance of wheat flour as a staple food, its energy value, protein content and digestibility have been extensively studied. McCance, Widdowson, Moran, Pringle & Macrae (1945) and McCance & Walsham (1948–9) who have made detailed investigations have referred to the earlier literature on the subject. We have found comparatively few data dealing with other foodstuffs or with mixed diets, which, rather than a single foodstuff, are normally consumed even by primitive or economically backward peoples.

We suggest that it is usually of greater practical importance to study the absorption of a mixed diet than of an individual foodstuff. It is well known that absorption, particularly of nitrogen, is adversely affected by the presence of fibre in the diet. It may be that the fibre causes an increase in faecal N derived chiefly not from the food consumed, but from the intestinal epithelium: it will nevertheless diminish the N available to the body. The fact that the nutrients of an individual foodstuff may be completely absorbed is only of academic interest if, from the diet of which it forms a part, considerable quantities of energy and N are lost in the stool.

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Apart altogether from the properties of the foodstuff consumed, intestinal absorption also depends on the condition of the alimentary canal of the consumer. In cases of intestinal disease this fact is so obvious as hardly to require mention. But apart from conditions in which malabsorption is a well-recognized feature, there may be others in which, though present, it receives less consideration than it deserves. Perhaps the most obvious is infestation by intestinal worms. In heavy infestations with the larger tapeworms, or with ascarids, it can hardly fail to be so, for the total mass of worms in the intestine may be very considerable and consequently they will require appreciable amounts of energy and N for their growth and reproduction, which they can only obtain by robbing their host. Jelliffe (1953) has considered this aspect of the matter, among others, with reference to ascarids. With other common parasites, such as hookworm, conditions are different, for the dry weight of a thousand or more hookworms amounts to much less than 1 g, and even with a heavy infestation (2000 or more worms) the actual metabolic demands of the creatures would be slight compared with the host's food intake. It has been claimed, however, that *Haemonchus contortus*, an intestinal parasite which infests sheep and which is similar in size and general habit to the hookworm, does inhibit N absorption (Stewart, 1932*a*) by producing an anti-proteolytic enzyme in the intestine (Stewart, 1932*b*).

Venkatachalam & Patwardhan (1953) have shown that moderate ascarid infestation causes an increase in the excretion of faecal N, too great to be explained by the N content of the ascarid eggs passed. This suggests that ascarids interfere with the powers of the host to digest protein. Several authors (Weinland, 1903; Hamill, 1906; Harned & Nash, 1932; Collier, 1941) have claimed that ascarids produce anti-enzymes. It has been supposed that these serve to protect the parasite from the host's digestive juices. As Venkatachalam & Patwardhan suggest, such anti-enzymes may also, in certain circumstances, interfere with the digestive functions of the host, as evidenced by their own observations, as well as those of Stewart (1932*b*).

There is also evidence that deficiency of digestive enzymes may arise through dietary protein deficiency, thus forming part of a vicious circle. Thompson & Trowell (1952) showed that in East African infants with kwashiorkor there was a deficiency, reversible by a diet rich in protein, of amylase, lipase and trypsin in the small intestine. Platt (1954) has produced figures showing that the 'apparent N digestibility' in five Gambian children aged 2–5 years was 53·3–75·1% (mean 58·1%), whereas similar figures for eleven European marasmic infants were 74·0–89·9% (mean 85·0%). Pellett (1957) records that the 'apparent digestibility' of N in a protein-depleted pig was initially 56%. Increasing the protein ration raised the figure to 84%, from which it slowly decreased after the protein ration had been reduced to its original value. Gadzheva (1956) studied the secretions of an isolated loop of dog's intestine. She claims that the proteins and nucleic acids of the intestinal juice were diminished both in concentration and in absolute amount when the animal was fed on a diet low in protein, and increased on one rich in protein.

DeMaeyer & Vanderborght (1958) have recently investigated the nutritive value for African children between 3 and 7 years old of skim milk, soya-bean flour, groundnut flour and a mixture of soya beans and groundnuts. The level of dietary protein given

was rather low, never reaching as much as 1 g/kg body-weight/24 h. They have given figures both for 'percentage absorption' as we have used the term, i.e.

$$100(\text{N intake} - \text{faecal N}) \div \text{N intake}$$

and for 'corrected percentage absorption', i.e.

$$100(\text{N intake} - (\text{faecal N} - \text{endogenous faecal N})) \div \text{N intake}.$$

The endogeneous faecal N was measured by determining the faecal N on a diet containing less than 8 mg N/kg/24 h. In view of some of the work quoted above, the validity of taking the faecal N on a diet free from or very low in protein as a measure of endogenous faecal N may be a little doubtful. The highest values found by DeMaeyer & Vanderborght for N absorption were 81·9% 'uncorrected' and 89·8% 'corrected'. They infer that their subjects showed an absorption defect.

It has often been remarked, though as far as we know never placed on record, that East Africans habitually pass several stools daily. We have, indeed, known Africans seek treatment for constipation when they were regularly passing one stool a day, which they considered abnormal. We have recorded the daily number of stools passed by seventy-eight adult male Africans, each observed over periods of 3–5 days. None was suffering from conditions that would be expected to cause frequent defaecation, but the average number of stools passed per man per day was 2·7. This is *prima facie* evidence of a large faecal output.

We have carried out a series of observations on the absorption of mixed diets by various groups of subjects. Our observations have been confined to the absorption of 'calories', i.e. of the total energy contained in the diet, of N, and sometimes of fat. One of our original aims was to discover whether or not hookworms diminish intestinal absorption. Apart from the 'controls', most of the subjects studied in Mwanza had hookworm eggs in their stool. After worming, however, the hookworm load proved to be small. The greatest number of worms counted was 315, and most subjects yielded fewer than 100. It soon became obvious that a worm load of this size had no effect on absorption. The figures found before and after worming have therefore been pooled in presenting the results. As will appear from the following paper, however, heavy hookworm loads (which seem to be very uncommon in Mwanza) do have an effect on absorption (Darke, 1959).

EXPERIMENTAL

Subjects and their diets

All our experiments were carried out on human subjects who, except when stated to the contrary, were adult male Africans. During the tests, unless otherwise stated, carmine stool markers were used, as described later.

Most of the work was done in Mwanza, but we have some results for subjects studied in Kampala. Results of these observations not relating to absorption have already been published (Holmes, Jones & Stanier, 1954; Holmes, Jones, Lyle & Stanier, 1956).

Group A_1. The subjects were ten inmates of the prison ward at Mwanza Hospital, on whom nineteen sets of observations each lasting 3 days were made. Their diet was:

morning, maize porridge made with water and a little milk; noon, stiff maize porridge (of the consistency of a dumpling) with beans; evening, rice with a curry made of vegetables and a little meat and occasionally groundnuts. It was their usual diet.

Group A_2. The subjects were six other inmates of the prison ward at Mwanza Hospital, eating the same diet as those in group A_1. Fourteen sets of observations each lasting 3 days were made on them. Stool markers were not used.

Group B. Fifteen inmates of our metabolic ward at Mwanza Hospital were studied in seventeen sets of observations each lasting 5 days. Their diet was: morning, maize porridge made with milk; noon, stiff maize porridge with meat and vegetable curry, and cottonseed oil; evening, rice and fish curry and occasionally bananas in addition. They had tea with milk and sugar thrice daily. All had received this diet for 2 weeks or more before observations were made.

Group C. One European male, two European females and two male African laboratory assistants were studied in five observation periods of 5 days each. During these periods the subjects consumed either the diet provided in the metabolic ward (as group B) or a European-type diet consisting of meat, fish, bread, vegetables, butter, jam, milk, tea, coffee and sugar. There was no 'preliminary period' for the Africans when they consumed the European-type diet or for the Europeans when they consumed the African-type diet.

Group D. The subjects were three inmates of our metabolic ward at Mulago Hospital, Kampala. Four sets of observations, each lasting 7 days, were made. The diet was essentially of a European type, consisting of bread, corned beef, cheese, butter, sugar, dried skim milk and jam. In these experiments nine similar individual daily rations were prepared, wrapped separately in Cellophane and stored in the deep freeze. Two were taken at random and used for analysis (Holmes *et al.* 1956), the remaining seven being consumed by the subjects.

Group E. The subjects were fifteen patients in the metabolic ward at Mulago Hospital. Values for N absorption only were available. For the most part they were patients mentioned in a previous communication (Holmes *et al.* 1954). Stool markers were not used; the observation periods for which records were available varied between 3 and 32 days. Eighty-nine observation periods are considered. The dietary N was calculated from the measured food intake and was checked by analysis over one period. There was good agreement with the calculated values. The subjects consumed a typical African diet, but with extra protein in the form of dried skim milk.

Group F. A group of five controls was studied in Kampala. Three were Europeans, one male and two females, and two were male African medical students. Stool markers were not used. One subject was observed continuously for 7, one for 11, one for 14 and one for 20 days; the fifth was observed over five separate periods of 3, 5, 8, 9 and 10 days. N intake was calculated from food tables. The Africans consumed their usual diet with extra protein as in group E. The Europeans took their accustomed diet, at times reinforced with dried skim milk.

Group G. Four schoolboys (two aged 18 and two 16 years) from Bwiru secondary (residential) school near Mwanza were studied. Four sets of observations each lasting 3 days were made. The subjects consumed an African-type diet consisting of maize,

rice, groundnuts, beans, some meat and fish, and occasionally bananas. Stool markers were not used.

For groups A_2 and G, only the values for N and energy content of the stool are considered, since the omission of stool markers and the short periods of observation might invalidate the values for absorption.

Principle and limitations of analytical methods

If the energy value and N content of the food and faeces are measured, the differences between them will (subject to certain limitations to be discussed below) measure the energy value and N content of the substances absorbed. The fact that the faeces include variable quantities of bacteria and intestinal débris and secretions is immaterial if, as is usual, the net gain or loss of N and energy to the body is considered.

We have expressed the absorbed energy or N as a percentage of the intake. This value is often referred to as the 'apparent digestibility'. Its use raises a difficulty because both energy and N are lost in the stools even in starvation, so that even were the ingested food completely absorbed, the 'percentage absorption' indicated by this method would not be 100. Also, with the same faecal loss of N and energy, a diet providing a low energy and N intake would necessarily appear to be less well absorbed than a richer one. It is therefore necessary, when comparing one group with another, or comparing the same individuals or groups on different diets, to take account of the food intake, as well as of the figure obtained for percentage absorption. If these facts are borne in mind, however, the interpretation of results presents no difficulty.

A possible source of error in measuring the energy and N contents of the faeces would be the formation of volatile substances other than water escaping before the faeces were passed or during subsequent manipulations. Such an error would tend to make the absorption appear greater than it really was.

No doubt the bulk of the N, both in food and faeces, is protein N, but some of it certainly is not. Free amino acids, purines, pigments and other non-protein nitrogenous substances are present, and some food plants contain considerable quantities of free amino acids. In any event, the factor 6·25, so often used to convert N into protein, is only an approximation, the N content of many proteins important in nutrition differing materially from 16%.

The ultimate energy value of any substance is its heat of combusion, as determined in the bomb calorimeter. In this instrument, however, N is converted into NO_2, whereas in the body, much of it is converted into urea and some into other products having an appreciable heat of combustion. The heat measured by the bomb for protein or protein-containing mixtures is therefore greater than the heat, or its energy equivalent, liberated in the body. Theoretically a correction could be applied, and such a correction is, in fact, made in arriving at the commonly used figure of 4·1 kcal for the energy value to the body of 1 g protein. In fact, the heat of combustion, as well as the N content of different proteins, varies considerably, and all the N of food and faeces does not represent protein. We think, therefore, that any correction that can

be made to allow for these factors becomes such a rough approximation that it is better omitted. If it is assumed (*a*) that all the N in food and stools is protein N, (*b*) that multiplication by 6·25 will bring it to a value for protein, and (*c*) that the heat of combustion of protein is 5·3 kcal/g in the bomb, and 4·1 kcal/g in the body, a correction can be made. When it was applied to the energy values for food and faeces we found that it made no significant difference to the figures we obtained for percentage absorption of energy. We have, therefore, given the actual figures obtained in our determinations, but it must be remembered that not all the energy shown as food energy is in fact available to the body from the diet consumed.

Measurement of food intake

Except where otherwise stated above, the food intake was measured as follows. As far as possible, dishes were chosen that could be satisfactorily mixed. When different items were served together, e.g. rice, and fish or meat curry, the servings of each were treated separately. The servings were weighed. One-twentieth of the amount was then weighed out on a balance sensitive to 100 mg and placed in a suitable receiver. One-twentieth of the volume of all beverages except water was also added to the receiver. The receiver served to accumulate all the food and drink samples for the individual until the end of the experiment. It was kept in the refrigerator without preservative (which would have interfered with the determination of energy value). No sign of fermentation or decomposition was ever noted. If any food was not consumed, it was kept, analysed, and the necessary correction applied.

At the end of the experimental period, the food samples were mixed in a Waring Blendor, water being added as required. The resulting 'soup' was evaporated to a small volume on a water bath, and dried to constant weight in an oven at 95–100°. The resulting hard mass was broken up, ground in a coffee mill, then finely ground with a pestle and mortar, and stored in glass-stoppered bottles until analysed. The material was hygroscopic, and samples were again dried to constant weight before analysis.

Collection of stools

Immediately before the first meal of the experimental period, the subject was given 2 g carmine in gelatin capsules. The stools were then watched, and were rejected up to and including that first containing carmine. Subsequent stools were collected and treated as described below. After the last meal of the experimental period, carmine was again given, and the stool collection continued up to and including that in which carmine was first seen. Each stool was collected in a tared chamber-pot with a lid. It was well mixed with a spatula and weighed and one-fifth by weight of the total was dried to constant weight in a tared dish. The samples of dried stool for each period were ground in a coffee mill and subsequently finely ground in a pestle and mortar and thoroughly mixed. They were stored in glass-stoppered bottles. Samples for analysis were again dried before weighing as the material was hygroscopic. The stools were not generally acidified. The purpose of so doing would be to prevent the possible loss of N in the form of ammonia. It would, however, increase the loss of any volatile fatty acids, H_2S, mercaptans and other volatile substances present: some of these will

inevitably be lost on drying, but drying is essential if the bomb calorimeter is to be used.

We carried out a series of N determinations to test whether there was a significant N loss from unacidified stools. The stools were well mixed, and a portion was removed for drying in the ordinary way. A known weight of 0·1 N-HCl was then added to the remainder and well mixed with it, and the acidity of the stool was checked with litmus. A further portion was then removed for drying, allowance being made for the weight of HCl added. The results are shown in Table 1. The N loss amounted to 5% and was very constant.

Table 1. *Nitrogen content of faeces collected from African subjects during a 5-day period*

Sample *A* Not acidified before drying (mg/g dry stool)	Sample *B* Acidified before drying (mg/g dry stool)	*A* expressed as percentage of *B*
54·1	56·9	95·1
61·0	64·6	94·4
70·1	74·2	94·5
73·4	77·2	95·1
55·9	60·1	93·0
73·5	76·2	96·5
	Mean	94·8

Chemical methods

N was determined by the Kjeldahl method, with copper sulphate and selenium dioxide as catalysts during incineration. Distillation was carried out in a Markham apparatus. The energy values of food and stool were measured in a Bertholet–Mahler bomb calorimeter. Fats were determined in the dried food and dried stools by the method of van de Kamer, Huinink & Weyers (1949).

Drying of the food and stool may cause the loss of volatile fatty acids. On the the other hand, if fresh stools are used, volatile fatty acids, which in any event are likely to be products of bacterial fermentation in the gut, will be titrated, and will give falsely high values for total fatty acid, since their titration value will be multiplied by a factor valid for a mixture of fatty acids of the molecular weight of those found in food.

RESULTS

Table 2 shows for the various groups the mean dry weights of stool passed per 24 h by a subject. It will be seen that there were wide differences between some of them. The dry weight of stool passed by the prison patients (group A_1) was much greater than of that passed by any of the other groups, and next in order comes that passed by the Mwanza ward patients (group B).

Table 3 gives the values for the energy value and N content per g stool. The differences for the energy value of the stool between several of the groups were statistically significant, e.g. those between groups B and D, and B and C (European diet). The greatest difference, however, that between groups A_2 and C (European diet), was only 12·0%. This finding shows that the quantity of stool passed chiefly determines the

energy loss, and that a difference of as little as 12% in the dry weight would be sufficient to offset any likely difference in the energy value/g.

For the N content of the stool, the differences were greater. Not only were several of them statistically significant, but that, for instance, between groups G and D amounted to 30%. Differences of this order might offset considerable variations in the dry weight of stool, and so influence the figure for percentage absorption.

Table 2. *Mean values with their standard errors for dry weight of stool passed by the subjects per 24 h*

Group	No. of observations	Dry weight of stool (g/24 h)
A_1 (ten prison patients)	19	98·3 ± 5·0
B (fifteen Mwanza ward patients)	17	59·3 ± 4·4
C (five Mwanza controls):		
On African diet	5	36·0 ± 5·1
On European diet	5	26·5 ± 2·5
D (three Kampala patients)	4	39·2 ± 6·6
E (fifteen Kampala patients)	89	48·5 ± 1·7
F (five Kampala controls)	15	31·9 ± 1·7

Table 3. *Mean values with their standard errors for energy and nitrogen contents/g stool*

Group	No. of observations	Energy* (kcal/g dry stool)	Nitrogen (mg/g dry stool)
A_1 (ten prison patients)	19	4·71 ± 0·02	57·0 ± 0·9
A_2 (six prison patients)	14	4·59 ± 0·05	50·9 ± 2·8
B (fifteen Mwanza ward patients)	17	4·67 ± 0·03	54·5 ± 1·9
C (five Mwanza controls):			
On African diet	5	5·04 ± 0·14	52·6 ± 2·0
On European diet	5	5·15 ± 0·17	61·4 ± 4·3
D (three Kampala patients)	4	4·98 ± 0·12	65·6 ± 2·5
E (fifteen Kampala patients)	89	—	61·0 ± 0·8
F (five Kampala controls)	15	—	51·2 ± 2·1
G (four Mwanza schoolboys)	4	4·58 ± 0·23	49·3 ± 2·2

* By bomb calorimeter.

Table 4 gives values for the energy and N in food and stools for the various groups, and the absorption calculated from these values.

As far as the energy absorption is concerned, there was an obvious difference between group A_1 (the prison patients) and all the remaining groups. It of course reflects the difference in the dry weight of stool, recorded in Table 2.

The difference between group C (European diet) and group C (African diet) was also statistically significant. The European subjects in group C were unused to the African-type diet and consumed it less readily than their own, which is reflected in the lower energy intake. The Africans, however, consumed the European diet very readily, though it was equally unfamiliar to them. (Only in group C had the subjects not consumed the diet under examination for at least 2 weeks before the tests were made.) The figures suggest that the European-type diet was better absorbed than the African. It is, however, possible that the unfamiliarity of the diet and the lack of a

'preliminary period' may have played a part in producing the result. Even so, it will be noted that the absorptions of energy and N by group C on the European diet were the highest recorded.

The figures for N absorption show that the absorption of the prisoners (group A_1) was much lower than that of the next lowest group, the Mwanza ward patients (group B). Their N intake was slightly higher than that of group B, almost the same as that of group F, and higher than that of group C on either diet. There can thus be no question of the comparisons being misleading because of differences in N intake.

There was no linear relationship between N intake and N absorption, or between energy intake and N absorption. The correlation coefficient was 0·113 for the former relationship and 0·036 for the latter. If the individual values are plotted, it is obvious that no curve can be drawn to fit them. It would, of course, be expected that if very low intakes of N had been studied, a relationship between N intake and N absorption would have been found, since even on a N-free diet, the faeces would contain some N, and as the dietary N was increased, it would at some point have equalled the faecal N loss.

Table 4. *Mean values with their standard errors for absorption of energy and nitrogen by the subjects*

Group	No. of observations	Energy			Nitrogen		
		In diet* (kcal/24 h)	In stool* (kcal/24 h)	Absorption (%)	In diet (g/24 h)	In stool (g/24 h)	Absorption (%)
A_1 (ten prison patients)	19	3795 ± 130	463 ± 24	87·8 ± 0·5	19·1 ± 0·5	5·6 ± 0·3	70·6 ± 1·3
B (fifteen Mwanza ward patients)	17	3476 ± 150	276 ± 20	92·0 ± 0·6	18·2 ± 0·7	3·2 ± 0·2	82·5 ± 1·2
C (five Mwanza controls):							
On African diet	5	2256 ± 331	179 ± 20	91·7 ± 0·8	14·1 ± 1·3	1·9 ± 0·3	86·7 ± 1·1
On European diet	5	2739 ± 204	134 ± 14	95·2 ± 0·3	15·9 ± 1·0	1·6 ± 0·1	90·0 ± 0·4
D (three Kampala patients)	4	3368 ± 197	197 ± 36	94·3 ± 0·7	23·8 ± 0·9	2·6 ± 0·4	89·3 ± 1·5
E (fifteen Kampala patients)	89	—	—	—	20·6 ± 0·6†	2·9 ± 0·1	85·0 ± 0·7
F (five Kampala controls)	15	—	—	—	19·0 ± 2·2†	1·6 ± 0·1	88·5 ± 1·1

Standard error for differences between the means for group C on African diet and on European diet: energy absorption = 0·38, nitrogen absorption = 0·52.

* By bomb calorimeter.

† By calculation from tables.

The standard errors for some of the groups in the tables do not make full allowance for between-individual variation. Such variation is not in fact large enough to affect the conclusions drawn.

Table 5 shows that worming makes no significant difference to absorption of energy or N.

Table 6 gives figures for the absorption of fat for a relatively small number of subjects. Those chosen were the Mwanza controls on the European- and African-type diets, together with some of the prison patients and some of the ward patients.

Table 5. *Comparison of energy and nitrogen absorption of Mwanza ward and prison patients with mild hookworm infestation, before and after worming*

	No. of observations	Absorption (value with its S.E.) (%)	
		Calories	N
Before worming	11	73·5 ± 2·0	88·9 ± 0·7
After worming	11	70·9 ± 2·2	87·6 ± 0·8

The absorption by the Mwanza controls on the European diet was significantly greater than both their absorption on the African diet and that of group A_1 or B. As, however, the quantity of fat excreted was almost the same for groups B, C (African diet) and C (European diet), and though somewhat higher was still low for group A_1, this result was probably due merely to the fact that on the European-type diet the intake of fat was much the greatest. If the individual figures for fat absorption are plotted against fat intake, the points can be fitted fairly well to an exponential curve.

Table 6. *Mean daily fatty-acid content of food and stool and mean values with their standard errors for absorption of fat by the subjects*

Group	No. of observations	Food (g)	Stool (g)	Absorption (%)
A_1 (four prison patients)	8	25·7	5·2	79·0 ± 2·2
B (thirteen Mwanza ward patients)	14	29·2	2·9	85·3 ± 3·1
C (five Mwanza controls):				
On African diet	5	25·5	2·8	88·5 ± 1·7
On European diet	5	95·2	2·8	97·0 ± 0·4

DISCUSSION

The use of the values 4·1 kcal/g for the heat of combustion of protein, 4·2 kcal/g for that of carbohydrate, and 9·3 kcal/g for that of fat in the body, together with corresponding figures of 4·0, 4·0 and 9·0 (F.A.O.: Committee on Calorie Conversion Factors and Food Composition Tables, 1947) in calculations of energy values from analytical data for food, assumes that protein is absorbed to the extent of 97·5%, carbohydrate to the extent of 95·2%, and fat to the extent of 96·8%. McCance *et al.* (1945) have considered this question at length for wheat flours of various extraction. They concluded that these values give nearly correct results for flours of 85% and 75% extraction, but that the absorption is less with flour of 100% extraction.

We are not dealing with a single foodstuff but with mixed diets of two main types, the one commonly consumed by Africans, the other by Europeans. In two groups only did we find an energy absorption of or near 95%, and these were the Mwanza controls (group C) on a European-type diet, and the Kampala patients (group D). All the diets had relatively high energy values.

It seems, therefore, that the methods in current use for calculating from the results of dietary analysis the energy and N available to the body may err on the optimistic side, especially with African-type diets.

In considering the figures for N absorption it should be remembered that some faecal N must always be excreted. A figure for stool N of 1 g/24 h would not be exces-

sive, and on an intake of 10 g/24 h, it would give an absorption of 90%. In all our groups, however, the N intake was greatly in excess of 10 g/24 h. Only with the Mwanza controls, on a European-type diet, did the absorption reach 90% on an intake of 15·9 g N/24 h. For all other groups the absorption was less than 90%, and for the prison patients it was as low as 70·6%, in spite of an intake of 19·1 g N/24 h.

Since in tropical countries the outstanding dietary deficiency is often believed to be of protein, this observation is obviously of particular importance. We are at present unable to account for the difference in N absorption between the prison patients and the ward patients, except that whereas the N intake of the former was derived largely from beans that of the latter was chiefly in the form of meat, milk and fish. It is known that a high fibre content diminishes N absorption, and the fibre content of beans is given as 4·4% (F.A.O., 1953). On the other hand, we fed three of our ward patients, whose absorption had previously been measured, on a diet from which meat and fish were absent, and in which an equal amount of N was given in the form of beans, and found no decrease in absorption. Even the ward patients, however, only achieved an 82·5% absorption on an intake of 18·2 g N/24 h.

Since there is always some faecal fat present, it is only when the diet contains considerable quantities of fat that apparent percentage absorptions of fat are high. The faecal fat may be formed in the gut by bacteria from other substances, and we do not think that the apparently low percentage absorption figures on a diet very low in fat are of great importance in the present context.

McCance & Walsham (1948–9) showed that absorption was less on 100% extraction wheat flour than on flour of lower extraction, and they agreed with earlier workers that this lowering was due to an increased fibre content. We endeavoured to carry out some estimations of fibre content of our mixed diets, but were not satisfied with the accuracy of the results. It seems likely, however, that the lowered absorption on many African-type diets may be partly due to a fibre content greater than that of diets of the European type. We suggest that further investigation is needed of the absorption of various types of mixed diets.

There remains the question of the absorptive capacity of the individual. It is not necessarily related to the type of diet. As far as the influence of intestinal parasites is concerned, although there is evidence that absorption is hindered by the presence of ascarids in the intestine, we have found that light hookworm infestations have no apparent effect. There is also evidence that a previous diet poor in protein by itself diminishes N absorption. Thus, not only the present condition but the previous nutritional history of the subject may be of importance. Moreover, a poor N intake, by diminishing absorption, may set up a 'vicious circle' mechanism.

We do not wish to appear to exaggerate the practical importance of diminished absorption. When food supplies are freely available, no doubt defects in absorption are automatically compensated in an otherwise healthy individual by an increased intake. Unfortunately, food supplies, particularly of protein, are often limited by economic and religious considerations, and by taboos imposed by superstition or local custom.

SUMMARY

1. Studies in intestinal absorption of energy, nitrogen, and sometimes of fat, have been carried out on groups of African subjects, and on African and European controls.

2. The results showed a wide variation in the mean dry weight of stool/man/24 h passed by the various groups; significant differences of both energy value and N content of stools in the various groups were found.

3. There were significant differences in the absorption of energy and N between the different groups.

4. It has been shown that a mild hookworm infestation has no effect on the absorption of energy or N in patients with an adequate diet.

5. The significance of these results is discussed.

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