TREATMENT AND PREVENTION OF KWASHIORKOR*

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SYNOPSIS

Recent research carried out on kwashiorkor in Kampala, Uganda, is discussed. The first essential in both the treatment and the prevention of this disease being a diet rich in protein (preferably animal protein, to ensure an adequate intake of vitamin B₁₂ and a satisfactory mixture of amino-acids), methods of incorporating sufficient protein into children's diets were investigated.

For the treatment of severe cases, two high-protein diets—one based on animal protein, the other on plant protein—gave good results. In the first, the protein was obtained from dried skimmed milk and a calcium caseinate preparation known as Casilan; in the second, it was supplied by soya. Some vitamin B₁₂, which is lacking in the soya itself, was added to the second diet in order to ensure satisfactory weight gains.

With regard to prevention, the author points out that although it is theoretically simple there are serious practical difficulties. The best sources of protein—milk, meat, and fish—are unfortunately, at present, too expensive for general consumption in Uganda. Therefore, the best possible use of plant protein must be made for the time being. In this connexion, the author recommends investigating the value of sunflower, which grows more easily in Uganda than soya. He feels that soya, sunflower, and maize could probably be combined to provide a mixture of amino-acids which—though not as perfect as that found in animal proteins—would be very satisfactory.

The Dietary Background of Kwashiorkor

The disease "kwashiorkor", as we see it in Kampala, Uganda, occurs most frequently in the children of poor people, most of them peasant cultivators, whose basic diet is plantains, sweet potatoes or, in a few cases, cassava. In the vicinity of Kampala, meat, fish, and milk can almost always be bought, but all these are expensive and cannot be produced on the home plantation. We find, however, that all except the very poorest

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families buy meat once or twice a week, and fish almost as often, but that it is very unusual for such families to buy milk. The child who comes to us suffering from advanced kwashiorkor is nearly always from a family that buys no milk at all, or only enough to put in tea occasionally.

It is of course difficult to find out how much of the meat and fish bought for the family is given to the children. It seems to be a very small amount, and there is no doubt that the intake of animal protein is extremely small. It follows that there is equally little doubt that the intake of "animal protein factor", or of vitamin B₁₂, is also small. A vegetarian diet may also be lacking in certain amino-acids, in particular, the essential amino-acids lysine and methionine, and it is as well to bear in mind that one of the most important reasons for including some animal protein in a diet may be that its amino-acids supplement those of the rest of the diet.

In the diets of Kampala children, only one plant food rich in protein appears at all often: that is the ground-nut, which is eaten almost every day, but which is to some extent seasonal, is expensive, and is not easily digested by a child. Even with the ground-nut, we think it likely that the intake of protein from all sources by one of our children, when at home, is seldom more than 10 to 15 g daily.

It also seems likely that, as the staple foods are very bulky, the small child, however willing he may be, cannot eat enough to supply all the calories he really needs. The average age of admission of our cases of severe kwashiorkor is about 1½ years. At this age in Britain or the United States of America a healthy child is taking about 1,200 calories daily. If we assume that only 80% of the African child's calories have to come from the staple foods—the true figure must often be much higher—we arrive at the figure of 1,000 calories which these foods must provide. Plantains and sweet potatoes, as they are eaten by our people, yield only 70 calories per 100 g, and the child is therefore faced with the gargantuan task of eating 1,500 g of its basic food daily. But the child who has kwashiorkor is no Pantagruel: he has a poor appetite and is probably only half as heavy as he should be at his age. We know from our own measurements of the food intakes of children in hospital, that only those who are very well can take 1,500 g of any food daily, and that the sick child can seldom be persuaded to take more than 500 to 600 g. So there may be an element of starvation in kwashiorkor, especially in the later stages.

We know also that there is the element of defective absorption and utilization of the food that is eaten. Many of the children have a history of vomiting, and of bouts of diarrhoea, and the pancreatic enzymes are reduced in amount. The stools contain a great deal of undigested material, and much of the food is lost in them. Finally, we know that there is an intolerance of fats, including milk fat, and of sugars, including lactose.

We are now in a position to summarize. It seems reasonable to treat kwashiorkor with diets that might make up for the deficiencies in the home

diets, and that avoid the noxious foods. The diets, therefore, must contain as much protein as possible. A good proportion should be animal protein, so that we may be sure of giving also enough vitamin B₁₂, and a satisfactory mixture of amino-acids. The food must be easily assimilated, preferably fat-free, and its carbohydrate should not give rise to any digestive disturbance.

I intend to deal first with the way in which we have approached this problem of finding a suitable diet, and afterwards to discuss the possibilities of adapting our findings to the prevention of the disease.

Treatment with Milk

We started with the conviction that the protein of cow's milk must be the ideal kind of protein. We knew that milk had been used extensively in the treatment of kwashiorkor, and that the best results seemed to be obtained with skimmed milk. We therefore decided to use skimmed-milk powder ; this contains 34% protein, and when we wanted extra protein, we added the calcium caseinate preparation called Casilan, which contains 80% protein. A mixture of two parts of the dried milk and one part of the Casilan has as much protein as carbohydrate, and we have used it to provide children with over 100 g of protein daily, or between 15 and 20 g of protein per kg of body-weight. That was probably an unnecessarily large amount; we have had good results from as little as 25 g of protein daily, and we now consider that 50 g are enough. This is 8 to 10 g per kg of body-weight.

We could not use the dried skimmed milk alone to provide all the protein, because for every 34 g of protein there are 50 g of lactose, and as we increased the lactose so we increased the intestinal upsets ; the stools became watery and highly acid, and all the organisms except those which were acidophilic disappeared from the gut. We have described elsewhere ¹ how we came to use first the cooked banana (plantains) and later the sweet uncooked banana as the chief source of carbohydrate. Both of these foods seem to bring about some delay in the passage of food through the intestinal tract, and although absorption must be incomplete, it may be increased by the longer time available. It is possible, sometimes, to bring about improvement in the child's condition without the stools being formed, but, as a general rule, it is advisable to ensure formed stools quickly, and the bananas of both kinds will do that.

The bananas also help considerably in the supply of calories, not only by their own contribution, but also because they are a good vehicle for lactose and other sugars, which they make innocuous to some extent. Ideally, we should probably supply about 1,000 calories daily, or 150

¹ Dean, R. F. A. (1952) *Brit. med. J.* 2, 791

calories per kg of body-weight, but in the first few days after a child has been admitted to hospital, we pay little attention to his caloric needs. We concentrate on giving protein, and are quite content if he takes only 500 calories, provided that a high proportion—perhaps one-half—is in the form of protein.

The principles of treatment are easily illustrated. Throughout 30 days of treatment, one child received about 50 g of protein daily. At first, the protein was given in the form of dried skimmed milk, but the stools were loose. On the 9th day we introduced the dried-milk—Casilan mixture, and at once the stools became formed. The change in the diet reduced the carbohydrate from 215 g to 40 g. On the 18th day, when the child's clinical condition was greatly improved, we wanted to increase the caloric value of the diet, and so we returned to dried skimmed milk and sugar. At once the stools deteriorated : 145 g of carbohydrate were too much for the child at that time. A brief return to the skimmed-milk—Casilan mixture reduced the carbohydrate to 40 g again, with good results, and after that, the child was able to tolerate first 75 and then 125 g of carbohydrate. There was a temporary improvement in weight that started when the caloric value of the diet was raised on the 18th day, but it was followed by a considerable loss of weight, and there is no doubt that the diarrhoea was the cause. There must have been a large loss of body-water, and at the same time there was undoubtedly a loss of much of the dietary protein.

The child was exceptional in that from the first she ate all the food we offered. Her recovery was not complicated by any other illness. Many of the children, however, pass through a period of more or less acute anorexia, in which feeding by gastric tube is necessary, and some of them have their recovery interrupted by an infective condition. For instance, one child had the anorexia, and also a pneumonia. She was treated at first with a mixture of glucose and skimmed milk, of which she took varying amounts, and her stools did not become satisfactory until the concentrated milk protein replaced the dried milk, with cooked banana as the chief source of carbohydrate. By the 15th day it seemed as though she was well on the way to recovery ; weight was being gained and there was marked improvement in the clinical condition. Then the chest infection developed ; it was checked by streptomycin, but about 0.5 kg of weight was lost in the next five days. When the chest cleared, the weight began to increase again, and the rest of the progress was excellent. We finally incorporated 100 g of maize daily into the skimmed-milk—banana mixture.

Our estimate of the caloric intakes may be slightly exaggerated, because we have assumed that 80% of the carbohydrate in the cooked banana is available. We think, however, that there was a true relation between the caloric intake and the weight gain. We were able to maintain an apparent intake of more than 500 calories daily nearly all the time, but for satisfactory growth it was necessary to supply at least 1,000 calories daily.

Treatment with Soya

Another child was treated throughout with a mixture of soya bean, cooked banana, sugar, and a vitamin mixture that included about 15 μg of vitamin B₁₂. He had a fairly good appetite, even at the beginning, and he had a high caloric intake—always over 800 daily. When we are feeding children on diets of this kind, we notice sometimes that the loss of weight does not match exactly our observations of the loss of the oedema. We hope, but have not so far proved, that this indicates a rebuilding of body tissue, accelerated by the high caloric intakes, which is going on simultaneously with the removal of the oedema.

In calculating the calories, we omitted the contribution of the carbohydrate of the soya. It is a curious collection of pentosans, galactans, and waxes, with a little dextrin and sucrose, and, as someone has said, soya would probably be better without it: the child is probably none the better for having it. We gave this child 100 g of sucrose daily and the stools were not quite as well formed as when we restricted the intake of sugar to a lower figure, but there was no diarrhoea. The total carbohydrate, even with the soya carbohydrate omitted, and with the low estimate of the banana carbohydrate, was quite considerable.

I shall describe later the method we use for preparing the soya—a method which preserves the soya fat. This may seem to contradict what I have said previously about the need to omit fat from the diet. Milk fat, even in small amounts, causes diarrhoea, and we were afraid that soya fat would do the same. However, the latter has the reputation of being well tolerated, and that seems to be so in kwashiorkor. Twenty to thirty grams daily, the amount this child took, made a useful contribution to the caloric value of the diet.

To pass from cooked banana to sweet banana was a small and obvious step. Sweet banana has been used for many years for the treatment of coeliac disease, which resembles kwashiorkor superficially in some ways, differing perhaps most strikingly in its response to high-protein therapy. The ripe banana becomes a mixture of glucose and fructose, which has a flavour that all children seem to enjoy, and which is remarkably bland. It contains less fibrous and indigestible material than the cooked banana, is very cheap—at least in Kampala—and is available all the year round. It has the further advantage of not needing to be cooked.

Sweet banana has now been used in the treatment of many cases of severe kwashiorkor, and it has proved its value as a source of carbohydrate and as a vehicle for milk and soya protein. When we are using the soya-banana mixtures, we add the vitamin mixture I have already mentioned, in amounts sufficient to supply about 15 μg of vitamin B₁₂ daily.

Weight Gains during Treatment

Our cases of kwashiorkor usually stay in hospital about 28 days. At the end of that time, the mothers see their children apparently healthy, and without any oedema or skin lesions, and with good appetites, and want to take them away. At the end of 28 days' treatment, however, the weight is usually not much more than it was when the child was admitted, and when 20%-30% was the weight of oedema fluid. We wondered if the children's capacity for growth was impaired irreversibly.

All our work has been controlled as far as possible by animal experiments. New diets, and variations in the diets, are always tried on weanling rats before they are given to the children, and we have learnt a great deal from this method of comparison. In some of our experiments which were primarily designed to simulate the production of kwashiorkor, we gave diets of banana with various supplements that were just sufficient to keep the rats alive, but were inadequate for growth. When we changed the rats to a full, high-protein diet, they responded, even if they had not grown in the past hundred days, by growing at a fantastic rate, and continued at this rate until they reached the standard weight for age. Then a normal rate was resumed. The rats who had gone through these experiments seemed to be perfectly healthy.

We have had very few opportunities of trying to do anything similar to our children over a comparably long period, but we have one child who has been with us for nearly a year. She was not a very severe case of kwashiorkor, and the reason for her admission was malaria, but it was noticed that she had oedema, and pale skin and brown hair, and so she was transferred to us. For the first 100 days she had a diet of dried skimmed milk, sugar, and either rice, cooked banana, or sweet potato. This diet provided about 60 g of protein and 1,050 calories. She improved in clinical condition, but after 40 days' treatment had merely got back to her weight on admission, and after that only gained about 1.0 kg in the next 60 days. She had a few slight attacks of malaria which caused some pyrexia.

On the 100th day we changed her diet to 750 g of sweet banana, 375 g of our soya preparation, and 75 g of sugar, with the usual vitamin supplement. The total protein was increased to 75 g and the calories to 1,350. There was a considerable speeding-up of the rate of growth for the next 60 days. Then, with the diet unchanged, and possibly because of some infection that we could not identify, but which caused slight rises of temperature, there was a period of unsatisfactory growth. By the end of the next 100 days no more weight had been gained. On the 260th day we started to add each day to the diet, which already contained, as I have said, about 15 μ g of vitamin B₁₂, an absorbate that provided another 120 of μ g of the vitamin. That was the only addition we made, but the results were remarkable. There was an immediate resumption of the most rapid rate of growth. This rate was still

being maintained when, a few weeks later, the child was taken away from hospital.

It is interesting to compare this child's growth curve with the standard growth curve of an American child of the same age. At the beginning, the African child was 5.0 kg underweight. In the first 160 days, she gained 3.5 kg. A normal American child would increase by about 1.0 kg in the same time, so that the African child was growing $3\frac{1}{2}$ times as fast. This is exactly what we found was likely to happen when we were feeding mildly under-nourished German children, none of whom were suspected of having kwashiorkor, shortly after the second World War, and I think it gives us grounds for hope that, with proper treatment, the damage done to the children is, after all, not permanent. The apparent effect of vitamin B₁₂, when given in very large doses, reminds us of the effects obtained recently by some American workers² who gave vitamin B₁₂ to children who were suffering from what was called "simple growth failure"; the children were smaller than they should have been and there was no discoverable cause. The children's diets already seemed to contain adequate amounts of vitamin B₁₂, but there was a notable increase in growth when a further 10 μ g was added each day.

We have given the vitamin-B₁₂ adsorbate to other children with growth failure due to kwashiorkor, and in a few cases the results have been similarly gratifying in the short periods of our observations. It is possible, I suppose, but still very far from being proved, that huge doses of the vitamin may have a beneficial effect on growth, at least in the later stages of recovery when large quantities of protein are being taken. They may be needed because, as is well known, the requirement for the vitamin depends on the amount of protein in the diet.

Biochemical Criteria of Improvement

I have so far discussed success in treatment only in terms of clinical improvement and weight gains. We have, however, been able to establish some biochemical criteria for judging improvement.³ The levels for the serum constituents at the end of successful treatment are near to the levels we find in children who are admitted to hospital for the treatment of diseases such as pneumonia and malaria, and who do not bear any of the signs of kwashiorkor. It seems likely that some of the biochemical changes in the acute stage of kwashiorkor may be diagnostic features.

There is no doubt that, in the acute stage, there is poor utilization of any food given by mouth, and that as the child gets better, the utilization improves. This can be shown by balance experiments. One child treated for 25 days with the soya-banana diet, improved his absorption of nitrogen from 72% to 79%, and of fat from 86% to 96%. A child recovering from

² Wetzel, N. C., Fargo, W. C., Smith, I. H. & Helikson, G. (1949) *Science*, 110, 651

³ Dean, R. F. A. & Schwartz, R. (1953) *Brit. J. Nutr.* 7, 131

kwashiorkor—she was the child whose record over 300 days I have already described—in a balance period that started after 100 days' treatment with a milk diet, absorbed 79% of the nitrogen and 94% of the fat. A child who, as far as we can tell, never had kwashiorkor at all, but was under orthopaedic treatment for the paralysis of a leg—the result of anterior poliomyelitis—absorbed 80% of the nitrogen and 97% of the fat. All these figures relate to balance periods in which the children were given the soya-banana diet; the child last mentioned was given also the skimmed-milk—banana diet, and absorbed 88% of the nitrogen. This diet was, of course, fat-free.

Preparation of Soya

The method used in our laboratory for preparation of the soya is shown in fig. 1-4 (see pages 774-776). The beans are soaked in water for up to 48 hours, and swell. They are rubbed under water, to remove their husks, and the halves of the beans separate. The actual process of removing the husks is shown in fig. 2. The de-husked beans are minced and are packed into jars of the kind used for preserving fruit (fig. 3). The jars are filled with water and their tops are put on loosely. Then the jars are stood in water in a large boiling-vessel (fig. 4), and the water is brought to the boil and

FIG. 1. PREPARATION OF SOYA MEAL — I

boiled for ten hours. At the end of this time, the beans should have lost all their bitter flavour, and should be a soft mash, tasting slightly beany, but not at all unpleasant. Fig. 5 shows a day's ration for a child with kwashiorkor : 750 g of sweet banana, 300 g of the cooked soya, 75 g of sugar, and 3.5 g of the vitamin mixture. The ingredients are mixed as shown in fig. 6, or, preferably, in a high-speed electric blender, and then the diet is ready to be eaten.

Soya contains much phosphorus but very little calcium. To make sure that the children receive 1.0 g of calcium daily, we add 8.0 g of calcium

FIG. 2. PREPARATION OF SOYA MEAL — II

The husks are removed by hand and are washed away in a stream of water.

FIG. 3. PREPARATION OF SOYA MEAL — III

The de-husked beans are minced and packed into jars of the kind used for preserving fruit. The jars are filled to the base of the neck with the minced beans, and are then almost completely filled with water. The glass tops, with their rubber seals, are then applied, and the screw tops are fitted on loosely.

FIG. 4. PREPARATION OF SOYA MEAL — IV

The filled jars are placed in a large boiling-vessel, with water up to their necks. The water is brought to the boil, and is boiled for 10 hours. The resultant soft mash is made into a smooth paste by pressing between the finger and thumb.

lactate, or the appropriate amount of some other calcium salt. Sodium chloride can also be added, but this must be done with care if the child is oedematous, or is likely to become so. The return of oedema after it has been lost, which has been reported by some workers using various diets, may have been caused by the injudicious addition of salt.

The Prevention of Kwashiorkor

Milk, meat, and fish

I have devoted so much of my time to treatment, both at Kampala in the last two years and here in this paper, because it seems clear that the evolution of a successful method of treatment may give us an opportunity of finding successful methods of prevention. In theory, the prevention of kwashiorkor is not difficult : it is merely a matter of ensuring that the diet of every child includes enough protein, and that a good proportion of the protein is of high biological value. In practice, there are of course many difficulties, but I do not think any of them are insuperable.

It seems to be fairly well established that where milk is available for the children, there is hardly ever any kwashiorkor. The notable exceptions are

the people who eat sour milk and maize, and I wish I knew more about them. Either they eat very little milk and a great deal of maize, or the souring of the milk has some strange effects on amino-acids, or perhaps on vitamin B₁₂. In various experiments that we have done, milk and maize was an excellent diet.

FIG. 5. SOYA-BANANA DIET — A DAY'S RATION FOR ONE CHILD

About 60 g of protein, 25 g of fat, and 235 g of carbohydrate are provided. The caloric value is 1,320, of which 240 (18%) calories are from protein.

At no time in the near future can we expect to provide all our children with milk. Milk powder is the only practicable form in which to transport milk in the tropics, and the powder is far too expensive for general use. In Kampala, we are exceptionally favourably placed at one end of a railway running direct from the Kenya highlands where dried milk is produced, but the price is about two East African shillings per pound for dried skimmed milk. (The average monthly wage for an unskilled worker is between 40 and 50 East African shillings.) We have tried to encourage the production

of more dried milk, and a new drying plant was opened some months ago on the slopes of Mount Kenya, in spite of some unexpected troubles. The amount of milk available for drying is not very great, however, and depends to some extent on a seasonal surplus. The African labour force on the farms has for many years been given much of the skimmed milk, and recently more and more has been used for stock feeding; only after those demands have been satisfied is milk sent to the factories.

FIG. 6. SOYA-BANANA DIET — MIXING THE INGREDIENTS

Mixing may be done by hand, but it is preferable to use, if possible, a high-speed electric blender which produces a mixture of the consistency of thick cream.

In large areas of Uganda, the production of milk is hindered by cattle disease, and although work with preventative agents—especially chemotherapeutic ones—is being pushed ahead with fairly encouraging results, and although there are various small-scale improvement schemes projected, it will be a long time before much home-produced milk is available, and longer still before the milk has more than a strictly local distribution in the vicinity of the individual herds. We are working in conjunction with the Animal Health Department, whose interests in many ways coincide with ours, and where it has been shown that the poor nutrition of the local cattle is of itself an important factor in the question of poor milk yields. If the nutrition is slightly improved, and nothing else is altered, the milk yield rises steeply.

Meat is another food that is too expensive for us to use for the feeding of children. With proper husbandry, which includes good feeding, the local cattle would undoubtedly produce much more meat than they do at present, but difficulties of transport, and the lack of refrigeration, prevent the meat from taking an important place in the diet of the poorer classes, except in a town such as Kampala.

We have investigated the possibilities of using fish. The collection of fish on the Kenya coast, and from the lakes in the west of Uganda, is now organized by two European companies, and we wondered if it might be possible to obtain large supplies of fish, too small or unsuitable in some other way for ordinary marketing, that we could process for our children. It seems very unlikely, however, that large supplies will ever be available. The extension of the sea fisheries appears to wait upon two developments: knowledge of the kinds and amounts of fish available, and the systematic investigation of the various ways of catching the fish. The latter is an expensive piece of research for which a special ship, with special equipment, is needed. The western lake fisheries are, we hear, already finding that the average size of the fish caught is decreasing, and if that is so, the limit of economic production is not far away. Drying plants, and even canning plants, can only operate economically if the supply of raw materials is reasonably large and dependable, and constant, at least within a well-defined season. At the moment, the supply of fish is everywhere exceeded by the demand. With a ready market in the towns for all the fashionable large fish, and with the local African population taking everything else, there seems to be no hope of anything left over. It is worth noting, too, that the European fisheries—or fish-collectors, to be more exact—to ensure steady supplies are paying a price nearly double that formerly obtained by the fisherman. This may be good for him, but it is not so good for all the non-fishermen, who may now have to pay twice as much for their fish.

In Tanganyika, methods of fish culture have been under investigation for many years, and the Uganda Government has recently appointed a fisheries officer whose duty will be to encourage fish farming. Although, under good conditions, the annual yield of fish can be made to exceed a ton an acre (2.5 metric tons per hectare) of pond, it seems unlikely that fish farming will contribute largely to the national diet in the near future.

Although we agree that everything should be done to encourage the production of animal protein, we think it is obvious that for the improvement of the protein supply in the diets of young children—that is, for the prevention of kwashiorkor—we shall have to rely for many years on making the best use of our plant proteins. There is no doubt that much could be done by alterations in the patterns of agriculture, but to make such alterations effective may take as long as the improvement of dairy herds, and we need something that can be brought more quickly into operation.

Plant sources of protein

An obvious possibility, and one which is the particular concern of myself and my colleagues, is the production at a very low price of a dry food, rich in protein, which can be added to any basic diet. We used dried mixtures of malted cereals and soya for some years in Germany and they seemed to be of considerable value, but the manufacturing processes had to be very carefully controlled, and the final product was, I am afraid, too expensive for an African community. That is a pity, because the cereals needed—wheat and maize—as well as the soya are grown in East Africa in large quantities. We have not entirely abandoned the idea of utilizing the malting process, but we have put it aside for the time being.

We are handicapped by the almost complete absence of a food-processing industry in East Africa, and by the lack of packaging or canning plants. Everything has to be built from the foundations, as I imagine it will have to be built in nearly every country where kwashiorkor is prevalent.

The raw materials we hope to employ on a large scale are soya and sunflower-meal. The soya we used in the experiments I have described was grown on peasant holdings in the vicinity of Kampala, and cost 25 East African cents a pound. There are large sunflower-producing farms in Uganda, in which the Government has a substantial interest, and it is intended to increase the production of seed very considerably in the next few years.

Soya needs processing to remove bitter substances, and also to inactivate the trypsin inhibitor. There are various methods of processing, but the one we adopted in Germany, after various trials, was a prolonged steam treatment, which requires no special apparatus. The method I have described, the one we use at Mulago, is of course a kind of steam treatment.

Sunflower needs a little more apparatus, but most of it is standard agricultural equipment and not unduly expensive. The seeds have to be cracked, their husks removed, and the silver skins taken off the inner mass. A careful cold pressing can then be used to produce a fine oil, of high commercial value, and a meal with many excellent properties. The meal has about 35% protein and keeps well. We have not yet proved its value here in Africa, but our previous experience elsewhere, as well as that of workers in other countries, seems to show that it will be a great asset in our feeding schemes for children. The sunflower-seed protein is exceptionally rich in methionine. In the near future, we hope to repeat our kwashiorkor feeding trials, using sunflower instead of soya. This is particularly important for us because the amount of soya which can be grown in Uganda is limited—the length of day on the equator is not very suitable, and there is only a comparatively small acreage of the right kind of acid soil available—whereas it seems that the amount of sunflower

which could be grown is immense, and far exceeds the potential production of soya.

We want to use the soya and sunflower meals as the basis of high-protein supplementary foods. It may be enough to mix the meals, with perhaps some maize meal, and produce a dry food that has about 20% protein. We do not know how much further processing will be needed ; it may be advisable to cook the mixture of meals, but that would involve the further process of drying, and every additional process adds to the cost. We can incorporate during the mixing such minerals as are necessary and some vitamin B₁₂. We are negotiating for supplies of antibiotic waste materials that may be the best source of this vitamin.

The mixtures will be arranged so that as far as possible the deficiencies of one food are made up by the richness of another. For instance, in a mixture of soya and maize—a mixture that we used in Germany and have also used at Mulago—soya supplies plenty of lysine, which the maize lacks, and the maize supplies methionine, which the soya lacks. If yet more methionine is needed, some sunflower can be added. We have already done enough controlled experimental work with large groups of children of various ages to show that the principle of mutual supplementation is sound. It will never produce from plant materials quite such a perfect mixture of amino-acids as is found in the animal proteins, but we believe that the children will not notice the difference. Results obtained with a rapidly-growing experimental animal such as the rat, deliberately used to exaggerate an amino-acid deficiency, must not be applied without some adjustment to a slower-growing animal such as the child. We have data suggesting that the child is more tolerant of some of the theoretical deficiencies.

Our plans for large-scale improvements of children's diets are being worked out in co-operation with various Uganda Government departments, and especially the Animal Health Department at Entebbe, to which I have already referred, and the Agricultural Research Department. We hope to have processing plants which those departments will share : the best products will go to the children, and the rest to the making of concentrates for animal feeding. If, in the future, the Lake Victoria fisheries are developed, we may be able to use fish products in both kinds of food, and a site in proximity to the Lake is being considered. We may find it an advantage, and one that can be bought reasonably cheaply, to add a small amount of dried milk to the new foods, and, certainly, if other sources of protein become available, they will be made use of.

The problem of packaging seems to be capable of solution by the use of plastic tubing, which can be sealed perfectly with great ease. Distribution in packet form should not be too troublesome, and I think that the final problem, that of overcoming the prejudice against the use of a new food, is one that has been exaggerated. After all, the tin of condensed milk is a

highly unnatural conception, but is accepted everywhere ; we find that dried milk is used readily by mothers after a very little teaching, and we do not anticipate great difficulty in selling another dried food for children, provided that we can prove its worth and keep the price extremely low. We have been invited, by some of the owners of estates employing large numbers of African families, to watch the efforts they are making to ensure that the children are well fed, and we hope to find out, in large-scale trials on those estates, exactly what can be best done with the supplementary foods.

It must be obvious that this kind of scheme needs government support for all its details. Our own experience is that the sympathy and help of governments can be obtained most easily for schemes which combine reasonable theory with a visible possibility of practical application. It seems to us that, wherever kwashiorkor is found, it is necessary first to establish fairly securely the probable cause, and then to survey the local sources of foods that might be used for prevention. At that stage, industry or the Government can be expected to display an active interest.

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RÉSUMÉ

La maladie nommée kwashiorkor se présente le plus souvent, dans l'Ouganda, — et déjà à partir de l'âge d'un an et demi — chez les enfants pauvres, dont la nourriture manque de protéines animales, de vitamine B₁₂, et plus particulièrement de lysine et de méthionine. L'auteur expose les résultats obtenus dans le traitement hospitalier du kwashiorkor chez les enfants, à Kampala. Le traitement doit consister en protéines, essentiellement animales, afin que la vitamine B₁₂ et les amino-acides soient en quantité suffisante. La quantité d'hydrates de carbone du régime thérapeutique doit être calculée de façon qu'elle ne provoque pas de troubles digestifs. Le lait écrémé en poudre, additionné d'une préparation de caséinate de calcium, qui apporte des protéines sans augmenter la teneur en hydrates de carbone tels que le lactose, a donné d'excellents résultats. Des bananes, cuites ou crues, sont utilisées comme source d'hydrates de carbone. L'auteur indique les diverses étapes du traitement qu'il convient d'appliquer, progressivement, à divers cas.

La prophylaxie du kwashiorkor consiste à donner à l'enfant un régime assez riche en protéines de valeur. L'enfant qui peut boire du lait est pratiquement à l'abri de cette maladie. (On peut cependant citer comme exception les enfants consommant du lait aigre et du maïs, ce régime affectant probablement la teneur ou l'absorption des acides aminés ou de la vitamine B₁₂). On ne peut songer pour le moment à assurer du lait à tous les enfants. Le lait en poudre est trop coûteux pour que son emploi puisse se géné-

raliser sous les tropiques. La production laitière locale est, du reste, insuffisante. Dans de vastes zones de l'Ouganda la trypanosomiase des bestiaux entraîne une diminution de la lactation. Pendant longtemps encore, et malgré les mesures prises, la production du lait restera insuffisante et sa distribution ne dépassera probablement pas les régions d'élevage.

La production laitière est étroitement liée à la nourriture du bétail, elle-même déficiente. La viande est trop chère pour contribuer de façon notable à l'alimentation normale des enfants. Le développement de l'élevage pourra améliorer la production, mais les difficultés de transport et l'absence de réfrigération empêcheront pendant un certain temps encore la consommation de la viande par les éléments pauvres de la population. Il ne faut pas compter pour le moment sur l'industrie de la pêche, encore rudimentaire, pour compléter par du poisson l'apport en protéines.

Aussi est-ce au moyen de protéines végétales qu'il faut chercher à améliorer l'alimentation des enfants. A l'instigation de l'auteur, on cherche actuellement à mettre au point une nourriture végétale, sous forme desséchée, riche en protéines, qui puisse servir d'appoint au régime courant. L'obstacle est l'absence presque complète d'industrie des conserves alimentaires en Afrique orientale. Dans ce domaine, les pays où sévit le kwashiorkor ont tout à créer. Les matières premières utiles sont le soya et la farine de tournesol. Le soya est cultivé par les paysans et il existe des entreprises agricoles produisant de grandes quantités de tournesol. Le soya doit être traité par la vapeur pour éliminer les substances amères et l'inhibiteur de la trypsine, ce qui ne représente pas un problème technique sérieux. Les graines de tournesol sont décortiquées et pressées. La farine, riche en méthionine, contient 35% de protéines et se conserve facilement. Le tournesol peut être appelé à remplacer le soya dans les régimes pour enfants, les possibilités de culture étant beaucoup plus vastes.

Selon les projets exposés par l'auteur, la farine de soya et de tournesol — à laquelle on peut ajouter de la farine de maïs — constituera un excellent aliment d'appoint contenant 20% de protéines : le soya fournit la lysine qui manque au maïs ; ce dernier est riche en méthionine qui manque au soya. Des sels minéraux, de la vitamine B₁₂ (provenant éventuellement des sous-produits de la fabrication des antibiotiques) peuvent être ajoutés. Les végétaux ne peuvent assurer un mélange d'acides-amino aussi complet que celui que l'on trouve dans la viande, mais, dans le développement de l'enfant ces différences passeront inaperçues.

Les plans pour l'amélioration du régime alimentaire des enfants sont élaborés en collaboration avec divers services gouvernementaux de l'Ouganda, en particulier ceux de l'hygiène vétérinaire et des recherches agricoles. On peut espérer voir s'élever bientôt des fabriques dont les produits de qualité seront destinés aux enfants et les sous-produits à l'alimentation du bétail. L'industrie de la pêche et des conserves de poisson pourra à l'avenir offrir de nouvelles possibilités. La réalisation de ces projets n'est possible qu'avec l'appui gouvernemental. Partout où le kwashiorkor existe, il s'agit d'en chercher la cause probable et d'examiner quelles sont les ressources locales qui pourraient y remédier. A ce stade, l'industrie et le gouvernement témoignent généralement un intérêt actif à ce problème vital.