BACKGROUND INFORMATION ON THE DEVELOPMENT AT THE N.N.R.I. OF A SUPPLEMENT FOR THE PREDOMINANTLY MAIZE DIET

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Having investigated certain matters concerning human nutrition in South Africa, the so-called 'Mönnig Committee'[4] recommended as early as 1958 that research be carried out with a view to 'exploring the possibility of supplementing maize meal—particularly with milk powder and fish flour'.

This recommendation was based mainly on evidence that had been submitted by the National Nutrition Research Institute and by other CSIR research groups. In the Institute's own report published in 1959,[5] the recommendation, which has a bearing on the use of maize meal as a food, reads as follows: 'The question of finding the best conditions under which maize can be employed as a food for human consumption needs extensive investigation, since maize is the staple food of the non-European population, especially in rural areas'.

Certain Properties of Maize Meal as a Food

From the nutrient composition of maize meal it can be seen that the predominantly maize diet will tend to be deficient in certain respects. The relevant data are shown in Fig. 1: The various nutrients in that amount of sifted granulated maize meal,[9] which supplies the daily calorie requirement, are expressed as percentages of the recommended daily allowances for a young child 2 years of age and weighing 13 kg. The adoption of the allowances for a 2-year-old child as the standard for judging the nutrient value of maize is based on the fact that, according to data compiled by Trowell *et al.*,[7] the incidence of kwashiorkor is highest in this age group.

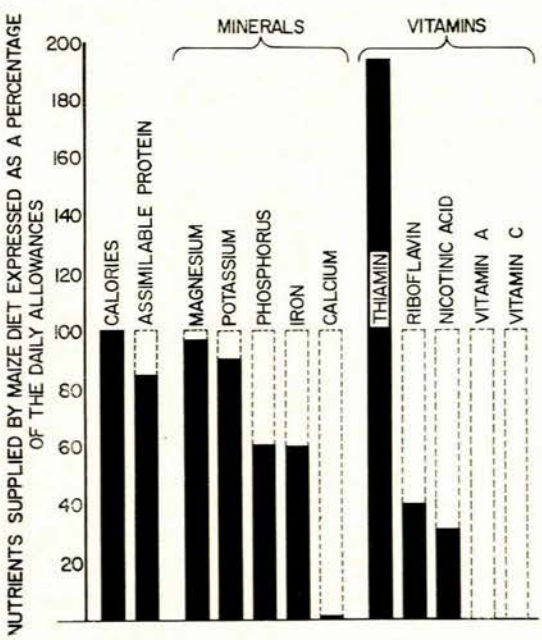

Fig. 1. The weights of certain nutrients in sifted granulated maize meal[9] expressed in terms of the recommended daily nutrient allowances for a young child, 2 years of age and weighing 13 kg. Allowances of most of the nutrients are those recommended by NRC,[6] exceptions being assimilable protein and magnesium which are those recommended by FAO[1] and Hansen[3] respectively. The allowance for phosphorus is based on the principle that the Ca:P ratio should be 1·2:1, and that for potassium is based on the finding that body potassium content increases at a rate of approximately 120 mg./G of nitrogen retained.[10]

We have assumed that it is possible for a 2-year-old child to consume an amount of maize meal that will furnish the recommended 1,300 kilocalories per day. About 317 G of meal would be needed for this purpose. It can be seen that in the case of most nutrients, and particularly calcium and certain vitamins (A, C, B_2 and nicotinic acid), this amount of maize meal does not supply the daily allowances. Surprisingly, the amount of assimilable protein provided is sufficient to meet almost 85% of the daily requirement. The allowances for magnesium and potassium are met almost entirely, whereas the amount of thiamine furnished is equivalent to almost twice the daily requirement.

Superficially, the supplementation of maize meal might seem to be a relatively simple matter, since the addition of a small quantity of assimilable protein and calcium salt plus a few micrograms of synthetic vitamins would eliminate most of the deficiencies. But, unfortunately, this relatively simple state of affairs is complicated by another factor. In South Africa maize meal is usually eaten as maize porridge, and it is seldom realized that maize porridge contains at least 70% water. This means that, for the 2-year-old child to consume 317 G maize meal, the capacity of the stomach must be such as to accommodate a weight of about $2\frac{1}{4}$ lb. of stiff porridge each day.

It seems reasonable to assume that the bulkiness of a maize porridge diet will seriously restrict the ability of the child to consume the required amount of calories, and may be responsible for the abdominal distension so frequently seen in Bantu children, and the craving for foodstuffs of high caloric density (e.g. sugar) so common in Bantu of all ages. In terms of caloric density the South American tortilla, which contains less water (about 50%), is undoubtedly a better food than maize porridge.

Another specific property of maize that has a bearing on the problem of improving the maize diet is its effect on iron absorption. Fig. 2 shows results obtained at the NNRI from experiments on iron absorption and the accumulation of non-haemoglobin iron (ferritin and haemosiderin) in the liver in 2 groups of young rats, the one having been fed dried maize porridge plus table salt and the other a laboratory-type balanced diet which contained, in addition to other ingredients, 52% maize dextrin and 15% defatted whole-egg protein. It can be seen that the rate of absorption of iron and its rate of accumulation in the liver depend not only on the weight of iron consumed but also on the type of diet fed, both absorption and accumulation being greater in the rats fed on maize porridge than in those fed on the balanced diet.

The nutritional properties of maize as outlined serve to explain to a considerable degree certain features of the health status of maize-eating communities, e.g. the ex-

treme rarity of beri-beri and the high incidence of kwashiorkor, pellagra, ariboflavinosis, the high iron content of the liver and the prevalence of certain liver diseases.[3] It should be noted, however, that for some reason as yet

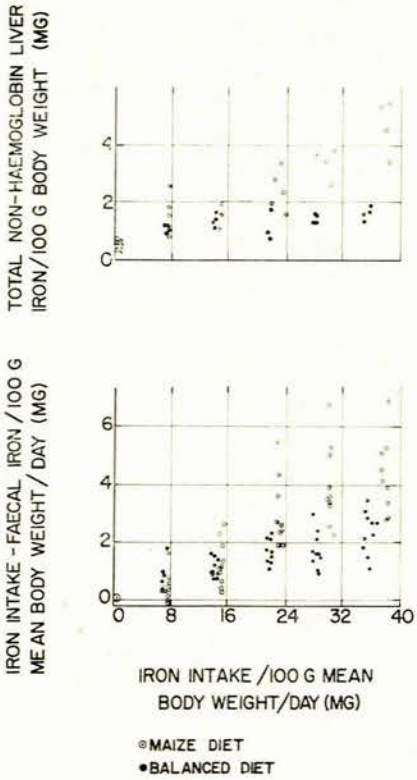

Fig. 2. The relationship between iron intake, iron absorption and the accumulation of non-haemoglobin iron in the liver in 2 groups of rats, the one group having received dried maize porridge plus NaCl and the other a laboratory-type balanced diet. Each rat group consisted of several smaller groups fed, in addition to the experimental diet, a specific weight of ferric citrate. Absorption was measured by the balance technique over a period of 10 days which followed on an initial 7-day adjustment period. The liver analyses were done on a number of animals selected from each of the two main groups on the 27th day of the experiment.

unknown the low vitamin C and calcium contents of maize are not specifically reflected in the disease pattern of the Bantu. Moreover, compared with Whites, the Bantu occupy an enviable position in respect of the incidence of coronary heart disease, diabetes, gallstones, iron-deficiency anaemia and stones in the kidney and bladder.[5]

Improvement of Maize as a Food

Because of the relative simplicity of the Bantu diet with its low content of protective foods, as well as for other reasons, particularly the fact that Bantu are suspicious of all forms of maize meal which differ from the usual product in taste and colour, there are great practical difficulties in the way of improving the maize diet of the Bantu.

Gilbert and Gillman[2] have shown that the addition to maize meal of a particular mixture of foods, which would be considered a 'good' supplement even by experts, causes nephrocalcinosis in rats. We have confirmed these findings, obtaining calcium stones of the type shown in Fig. 3.

Further investigation by us has shown that the stone formation is due to a calcium-phosphorus imbalance which can be prevented by the addition to the diet of a calcium salt such as calcium carbonate. The calcium content of

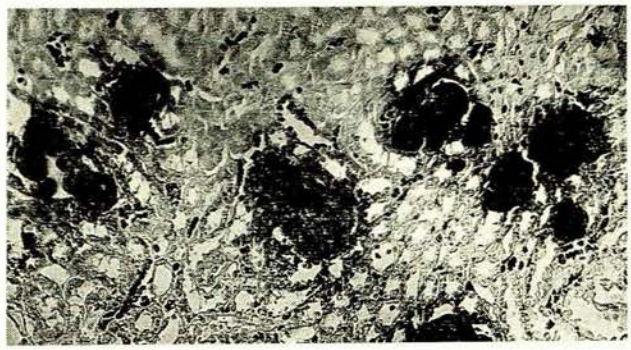

Fig. 3. Calcium stones in the kidney of a rat fed on a maize diet supplemented with cooked soya meal, food yeast, balanced mineral mixture and vitamins A, E and D at the levels employed by Gilbert and Gillman,[2] for 200 days. The section was stained with alizarin. The incidence of nephrocalcinosis in rats under the above conditions is from 70 to 100%.

the simple maize diet is thus too low to afford protection against a supplement which is too high in phosphorus content. Observations such as this and many others made by Gilbert and Gillman[2] illustrate some of the intricacies of the task of improving the predominantly maize diet.

The NNRI Committee on Special Foods

Since the termination of the bread fortification scheme in 1959, the NNRI has been investigating various means of combating malnutrition in South Africa. Our experience with the bread scheme has shown conclusively that the addition of macro-nutrients, such as proteins to staple foods, has grave disadvantages when carried out on a national scale, one of these being that the greater proportion of the funds spent on such a scheme is wasted on people who are not in need of additional supplies of nutrients.

It was obvious that a scheme was needed which would be more specific in its application to the particular needs of the situation. There was much evidence that malnutrition occurred mainly among the non-White population groups, particularly in infants and young children, and that milk consumption was very low among these groups. It is known that supplementation of a maize-porridge diet with milk is an effetive means of initiating and maintaining cure in children with kwashiorkor, and because of the urgent need for immediate action the NNRI strongly recommended, as a first curative and preventive measure, the direct distribution of skimmed-milk powder to needy infants and young children.[5]

Even before this recommendation was made, it was realized that available milk supplies might be inadequate to meet fully the needs of the situation. However, there was reason to believe that suitable mixtures containing other foods as well as milk powder could be developed for the purpose of reaching greater numbers of children.

With a view to combining the individual efforts of the various research divisions of the NNRI, particularly those of the Nutrition Clinic for Children and the Physiology

Division, the Director, Dr. F. W. Quass, appointed a special committee of staff members in July 1961 under the chairmanship of the late Dr. W. I. M. Holman. After preliminary discussions the Chairman, in an NNRI document dated 28 July 1961, outlined the purpose of the programme and indicated the two major aspects of the work that had to be done, viz., (*i*) the feeding of infants before weaning and (*ii*) feeding of infants and young children after weaning. The first aspect was essentially the problem of preparing a satisfactory whole-milk equivalent from skimmed-milk powder, and the second the development of a maize supplement.

In the initial allotment of work the Physiology, Protein Chemistry and Food Chemistry Divisions assumed responsibility for the collection of information on the nutritive values of 'protein-rich foods other than milk which are suitable either alone or in combination with other materials for use by young children'. Investigation of the paediatric aspects on the one hand and the food technological, agricultural, industrial and economic aspects on the other, was undertaken by the CSIR Nutrition Clinic for Children and by the Food Technology Division of the NNRI respectively.

Initially, progress of the work of the Committee was delayed to a considerable extent by the untimely death of the Chairman in December 1961, but a new Chairman, Mr. J. P. de Wit, was appointed and in March 1964 a tentative suggestion regarding the composition of a supplement for the predominantly maize diet was submitted to the Committee. At the following meeting (18 May 1964) the Committee entered a new phase of its operations, namely, the testing of the effectiveness, keeping quality, and acceptability of the proposed supplement.

Since some of this work is still in progress, it would be unwise to disclose the composition of the supplement at the present stage. The Committee has decided that this information, as well as the results of all the various experiments that have a bearing on the effectiveness and other properties of the supplement, should be made available to government departments as well as to other interested groups and individuals during a special symposium to be held late in 1965 or early in 1966.

It can be stated, however, that (*i*) all possible precautions are being taken to ensure that the supplement will be both effective and safe; (*ii*) the use of the supplement need in no way reduce the present consumption rate of either skimmed-milk powder or maize meal; (*iii*) the cost of the supplement per effective daily requirement will probably be less than that of skimmed-milk powder; (*iv*) the supplement will consist mainly of well-known natural foods; (*v*) the supplement will contain the necessary protective nutrients in exceptionally high concentrations, so that packaging and distribution costs will be lower than those of skimmed-milk powder; (*vi*) in the formulation of the supplement the NNRI has duly observed one of its major responsibilities, namely, stimulation of the production and distribution of those foods which at a given time are consumed in inadequate quantities by a given section of the population.

Future work might well reveal possible means of simplifying the supplement and thereby reducing its cost, but it should be realized that the 'complete' diet is a highly complex entity, and that in nutrition there is always greater safety in the proverbial spice of variety than in the monotony of the simple diet.

SUMMARY

A brief account, illustrated with results obtained in the laboratory and findings reported in the literature, is given of work done at the National Nutrition Research Institute (NNRI), in connection with the need for and the development of a supplement for the predominantly maize diet.

The limitations of maize porridge as a food for young children are emphasized and certain aspects of the problem of improving maize through supplementation are discussed.

The fact is disclosed that a special NNRI committee of research workers has tentatively formulated a concentrated supplement, the effectiveness, acceptability and keeping quality of which are now being investigated.

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