Phytic Acid

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Current views about the nutritional significance of phytic acid can best be appraised by approaching the problem historically. Mellanby (1921, 1925) demonstrated that cereals contain an anticalcifying factor, although he was not at that time able to isolate or identify it. He showed, however, that oatmeal was highly rachitogenic and that whole wheat flour was worse than white flour. When Bruce & Callow (1934) were studying rickets in rats due to insufficiency of phosphorus, they found that cereals were less effective as a source of phosphorus than inorganic phosphorus, and they suggested that the phosphorus present in cereals as phytic acid might be poorly absorbed. They recognized, moreover, that phytic acid might precipitate calcium very effectively in the intestine, and so prevent its absorption. Mellanby at once saw the importance of this, since a deficiency in the body of calcium but not of phosphorus is the usual cause of rickets in puppies or children, and Harrison & Mellanby (1939) demonstrated that the diet of puppies could be made rachitogenic by the addition of phytic acid. Here was positive proof of the dangers of a substance widely distributed in nature and frequently eaten in large amounts by man.

McCance & Widdowson (1942*a*, *b*) made the first human experiments. They showed that calcium was much less freely absorbed from diets consisting largely of brown bread than from those consisting largely of white, that the amount of calcium absorbed from brown bread diets could be raised by adding calcium to the bread, that the absorption of calcium from white bread could be prevented by adding sodium phytate to it, and that the absorption of calcium from brown bread diets could be improved by removing phytic acid from the bread. Their main conclusions were shown by Krebs & Mellanby (1943) to apply to flour of 85% extraction.

After these experiments calcium carbonate was added to the National loaf, and justification for the step came sooner than might have been expected. The shortage of wheat in Ireland during the war forced the Government to introduce whole wheat flour. It was not enriched with calcium and this step was followed by a considerable increase in the incidence of rickets in Dublin (Pringle, Reynolds & Jessop, 1943). Other things may have contributed to this increase but, on the whole, the evidence that it was a matter of cause and effect is strong.

Their interest in the metabolism of the pig led Danish workers to study phytic acid, but during the war they showed that it interfered with the absorption of calcium in puppies (Hoff-Jørgensen, 1946), infants (Hoff-Jørgensen, Andersen, Begtrup & Nielsen, 1946), and children (Hoff-Jørgensen, Andersen & Nielsen, 1946). The Danish work, and indeed the whole question of phytic acid, have been well reviewed by Møllgaard (1946). The Danes considered that diets high in phytic acid and low in calcium were nutritionally undesirable, and they recommended not only the addition of calcium to, but also the removal of phytic acid from, the bread of the country. This they were able to do because the common bread in Denmark is made from rye which contains such

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an active phytase that, by choosing the correct baking conditions, almost all the phytic acid can be hydrolysed while the bread is being made.

It is interesting to point out that oatmeal contains no phytase; this explains why it is so much more rachitogenic than wheat, rye or barley (McCance & Widdowson, 1944). It is curious that Cruickshank, Duckworth, Kosterlitz & Warnock (1945) should have found so much of the phytic acid in oatmeal to be hydrolysed by the subjects whom they studied but, since the calcium balances in their experiment were on the whole negative even with calcium intakes of over 1 g. daily, the hydrolysis probably took place too far down the intestine to allow the calcium to be absorbed.

Some apprehension about arterial sclerosis found expression in the popular press when it was decided to fortify the National loaf with calcium but its benefits have been generally recognized (Medical Research Council, 1947). It is, however, necessary to consider certain criticisms which have been levelled against the view that the absorption of calcium may be seriously interfered with by phytic acid.

Walker, Fox & Irving (1948) have recently published the results of some balance experiments on four adults. In the critical part of the experiments the subjects passed from their ordinary diets to one containing daily 1 lb. of bread made from flour of 95–100% extraction, and 10 mg. calcium/kg. body-weight. One hundred g. of the bread contained about 50 mg. of phytic acid phosphorus, which was considerably less than the amount in the bread used by McCance & Widdowson (1942*a*, *b*). On this regime the subjects were for a time in negative calcium balance, but ultimately they ceased to be so. Walker and his colleagues concluded, therefore, that it was unnecessary to fortify flour with calcium. They obtained no data which were in conflict with the results of McCance & Widdowson, but they considered that these authors had not continued their balance experiments for long enough, and hence that their recommendations had been based on insufficient data. This paper contains a review of the literature and deserves serious consideration, but it is better to take the results and the conclusions separately. The results may be dealt with in a few words. There seems little doubt that the subjects, in the conditions of the experiment, did gradually come into calcium equilibrium (see Widdowson, 1947). Everyone, however, might not have reacted as these few people did. McCance & Widdowson's subjects, who were eating much more phytic acid, showed no sign of coming into calcium equilibrium in 3 weeks. They might have done so ultimately, but some of them would have lost a considerable amount of calcium while doing so, and one of them would probably have had rather an uncomfortable time. At all events, a diet containing a large amount of whole wheat bread or oatmeal and no extra calcium produced most unpleasant attacks of tetany in one of the subjects (McCance & Walsham, 1948–9). Walker *et al.* (1948) state that their experiments extended over the different seasons, but it is just possible that their results were due to seasonal variations in calcium metabolism (McCance & Widdowson, 1943).

The conclusions of Walker *et al.* are in direct conflict with those of the British and Danish workers. They are essentially those of *laissez faire*, and similar conclusions have been drawn before (Nicholls & Nimalasuriya, 1939). No one will deny that most adults can maintain health on diets which contain very little calcium and much phytic acid, or that children can absorb enough calcium to grow on such diets, but it is less

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certain that they grow at an optimum rate. Sherman (1947) has recently pointed out that animals may live through their whole lives, and never have optimum concentrations of calcium in their bones or tissues. The same must be true of man, and those who have had opportunities of studying calorie deficiencies will see the obvious parallel. Given a somewhat insufficient number of calories, children do not fail altogether to grow, but they grow more slowly than they should. Walker and his associates do not seem to have given due consideration to the whole body of evidence which has been produced in England and Denmark. They have concentrated rather on specific parts of it, and until they have produced evidence that the growth of children cannot be improved by the addition of calcium to diets low in calcium and high in phytic acid it would seem wiser to act upon the recommendations of the Danish and British investigators. Anyone who considers that milk is a valuable food for growing children must hesitate before accepting such conclusions as those of Nicholls & Nimalasuriya or of the South African workers.

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The Rachitogenic Effect of Yeast

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Our observations are concerned with a deficiency disease in pigs apparently caused by a foodstuff included in a practical ration, but we are uncertain whether the disease was due to an antivitamin in the strict sense of the word, or whether some other explanation may ultimately prove correct.

Dried yeast is a concentrated source of protein and for this reason, quite apart from its content of vitamins of the B complex, it is now generally recognized as a valuable feeding-stuff for animals. In this country the interest in the product was increased by

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