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PHYTIC ACID AND PHYTASE IN CEREALS

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BY

SIR EDWARD MELLANBY

The interesting letter of Dr. R. A. McCance and Miss E. M. Widdowson in Nature of May 27 (1), in which they point out the relatively large quantity of phytase in wheat as compared with oats, gives me the opportunity of recording some further facts on this important practical issue which supplement those given in the letter. This is no mere academic question, but concerns what in the past certainly has been and in my view possibly still is, the most prominent problem of malnutrition affecting people in Great Britain.

Cereals form such a large part of the national dietary, namely, about 50 per cent. that, if they have a nutritional defect, it is certain to be of great consequence to health and development. What we must aim at is to get all the advantages of these valuable foods and at the same time to eliminate or prevent any baneful action they may have. Now, cereals have such a defect in that they are not only poor in calcium content but also they can, under some conditions, interfere with the availability to the body of calcium of other foods (2). This is of special importance to the child and adolescent, whose needs for calcium to incorporate in the growing bones, the developing teeth and other organs are great. In the adult animal also cereals can denude the bones of their calcium salts under some conditions. Contrary to all expectation, cereals such as oatmeal and maize, which contain most calcium, are just those which can interfere most with calcium deposition during growth.

In 1939 it was found that one substance in cereals which plays a large part in this harmful action is phytic acid (3). Any form of treatment which reduces the phytic acid in cereals either by eliminating it or by hydrolysing it will reduce the rickets-producing or anticalcifying effect. It was found that malting of cereals, and, more especially, germination followed by autolysis of the crushed grain, reduce this action; and now McCance and Widdowson have emphasized the importance of the hydrolysis of phytic acid that accompanies the change from flour to bread as the result of the action of the abundant phytase in the flour. They point out that oats and oatmeal, on the other hand, contain but little phytase to break down the phytic acid. They suggest that the difference in phytase content of wheat and oats explains the results described many years ago of the smaller rachitogenic action of bread as compared with oatmeal (2).

That this explanation is true is undoubted, but it is only part of the truth. Oats and wheat are both rich in phytic acid. In my experience oats are the richer source, but the variation in different samples of both grains is large and for the purpose of the argument we will assume that the amount is the same in each cereal and of the order of 200 mgms. phytic acid phosphorus in 100 gm. of the grain. Now the husk which is removed in the preparation of the oatmeal forms about 30 per cent. by weight of the grain, and since this husk contains no phytic acid (it does contain a little phytase) the percentage of phytic acid in the dehusked grain rises correspondingly, namely, up to 270 mgm. or more of phytic acid phosphorus per 100 gm. oatmeal. On the other hand, in processing wheat to flour, assuming that the wheat-meal flour is of 85 per cent. extraction, the 15 per cent. removed in the milling is largely made up of the coarser bran, which is very rich both in phytic acid and phytase. Thus 85 per cent. extraction wheat-meal flour would contain about 120 mgm. or even less phytic acid phosphorus per 100 gm. flour. Starting, therefore, with oats and wheat grain both containing 200 mgm. phytic acid phosphorus per 100 gm. of grain, by the time each preparation reaches the cook, there is a great difference between their contents: 270-300 mgm. phytic acid phosphorus in oatmeal and 120 mgm. in national wheat-meal flour; and this is not the end of the story.

In preparing these products for the consumer, the cook again alters their relative phytic acid content. The oatmeal is boiled as porridge, its small phytase content is destroyed and the phytic acid remains at the same high figure. In the case of wheaten flour, the matter is different. The high phytase content gets a chance of destroying phytic acid in the flour during the period when the dough is standing. In this process, however, the flour phytase is not the only phytase present. The added yeast is also rich in this enzyme and it may, under some conditions, assist the hydrolytic breakdown of phytic acid. Whether it does so assist seems to depend on the method of bread-making adopted. If the amount of yeast added is relatively large (2.1 per cent. of flour) and the time of standing of the dough short (2 hours), the yeast may add largely to the phytic acid destruction. If, however, the yeast added is small (0.6 per cent. of flour) and the dough rising-time long (6 hours), the yeast phytase may be ineffective. The phytase action of both flour and yeast is greatly increased as the pH is lowered towards 4.5, and it is possible that the additive effect of the larger amount of yeast may be partially or wholly explained by this change in pH. The accompanying results obtained on baking bread with flour at two levels of phytic acid content illustrate this effect of yeast.

Finally, it may be asked, what are the nutritional implications of this phytic acid-phytase problem of cereals? In the normal high cereal diet, three situations are presented: (1) when it contains much phytic acid, as when oatmeal or maize meal is largely eaten; (2) when it contains much inositol and phosphoric acid produced by hydrolysis of phytic acid by phytase, together with some unhydrolysed phytic acid, for example, when bread made from high extraction flour is eaten; (3) when it contains but little phytic acid or hydrolysed phytic acid, as when bread from low extraction flour or when a cereal such as rice is eaten. Since both inositol and phosphate are essential constituents of the diet, it is clearly desirable to have good supplies of these in the food, that is, conditions (1) and (2) above, but only so long as (a) these substances are available to the body and (b) neither phytic acid nor its product phosphoric acid is allowed to axert its calcium-stealing influence. Both these necessary conditions can be obtained by increasing the calcium in the diet and by maintaining a sufficiently high vitamin D intake. Man, especially the Scot, instinctively found the answer to this problem in the case of oatmeal by taking milk freely with his porridge. That is also the raison d'etre for the present practice of adding calcium carbonate to the modern loaf and vitamin D to the margarine, although it is probable that, in both cases, the present supplements are too small for the optimum calcium-phosphorus nutrition of many people.

Nutrition Building,
National Institute for Medical Research,
(Medical Research Council),
Mill Hill, N.W.7.

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(1) McCance, R.A. and Widdowson, E.M., Nature, 153, 650 (1944).

(2) Mellanby, E. Spec.Rep.Ser.Med.Res.Coun.,Lond., No. 93 (1925).

(3) Harrison, D.C. and Mellanby, E. Biochem.J., 33, 1660 (1939).

HYDROLYSIS OF PHYTIC ACID IN BREAD-MAKING

	Mgm. phytic acid phosphorus			
	Wheat-meal flour per 100 gm.	In bread per 100 gm. flour	Hydrolysed by phytase in 100 gm. flour	Probably hydrolysed by yeast per 100 gm. flour
SPECIMEN 1				
(a) High yeast; short rising time:				
(x) living yeast ...	75	29	25	21
(y) dead yeast	75	50	25	0
(b) Low yeast; long rising time:				
(x) living yeast ...	75	26	46	3
(y) dead yeast	75	29	46	0
SPECIMEN 2				
(a) High yeast; short rising time:				
(x) living yeast ...	174	77	76	21
(y) dead yeast	174	98	76	0
(b) Low yeast; long rising time:				
(x) living yeast ...	174	60	114	0
(y) dead yeast	174	57	117	0

High and low yeast = 2.1 per cent. and 0.6 per cent. respectively.
Short and long rising time = 2 hours and 6 hours respectively.