The Effect of Phytic Acid on the Absorption of Calcium and Phosphorus

3. IN CHILDREN

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In children the demand for calcium is particularly great and since their diet may contain considerable amounts of phytate, which is known to impair calcium absorption in adults (McCance & Widdowson, 1942) and in infants (Hoff-Jørgensen, Andersen, Begtrup & Nielsen, 1946), we have investigated the effect of a diet rich in phytate on the absorption of calcium and phosphorus in two children aged 10 years.

EXPERIMENTAL

Subjects

Both children were admitted to hospital complaining of bronchial asthma. At the time of the experiment their condition had been cured, and they were retained at hospital only for the sake of the experiment. Particulars of the subjects are given in Table 1.

Table 1. *Particulars of subjects*

Subject	Date of Birth	Date of Admission	Weight (kg.)		Complaint on admission	Treatment
J.T.	18. ix. 34	30. xii. 44	15. iii. 45	27·6	Bronchial asthma	From 30. i. 45: 5000 i.u. vitamin A, 1000 i.u. vitamin D_2 and 30 mg. ascorbic acid daily. 15 treatments with u.-v. light
			8. iv. 45	27·7		
			30. iv. 45	27·6		
			20. v. 45	27·9		
			31. v. 45	28·0		
M.H.J.	2. vi. 34	22. i. 45	15. iii. 45	37·5	Bronchial asthma	From 22. i. 45: as subject J.T., but no u.-v. light treatment
			8. iv. 45	37·9		
			30. iv. 45	38·2		
			20. v. 45	38·5		

Diet

From the time of admission to the beginning of the experiment the subjects received the ordinary diet of the hospital. The daily calcium intake was about 1·2 g. During the whole experimental period the subjects were given 500 g. milk daily and no cheese. Care was taken that the diet in the different experimental periods, each of 5 days, was as uniform as possible.

Danish rye bread and Danish rye vita (both of which according to the law are baked from flour made from 85 parts of rye flour (98 % extraction) and 15 parts of bran (80–98 % extraction), wheat bread baked from 100 % wheat flour and oatmeal porridge were given during the phytate periods.

During the periods with a low intake of phytate the bread was made from sifted rye (70 % extraction). This type of bread, made with leaven, is phytate-free. A small amount of wheat bread was given as wheat rolls (80 % extraction), and the porridge was prepared from barley grit which had been soaked in water overnight to ensure complete hydrolysis of the phytate. Milk and porridge (250 g.) were given at breakfast, and 250 g. milk and most of the bread at lunch. As an example of the composition of the diet during an experimental period of 5 days the data for the subject M.H.J. during period 4 are given in Table 2. With J.T. a further experiment was made (period 10) in which a phytate-free diet with 100 g. milk only was given daily for 5 days. The total calcium intake in this period thereby roughly corresponded with the intake of 'absorbable' calcium during the periods in which a diet rich in phytate was given.

Collection and analysis of excreta

The faeces of each subject were collected during each period in a covered glass bowl. The urine was collected under toluene after acidification with strong HCl. Carmine (1·0 g.) was used as a faecal marker to separate periods.

The analyses of food, faeces and urine were carried out as previously described (Hoff-Jørgensen, 1946).

Table 2. *Composition of the diet of subject M.H.J. during the 4th period*

Food	Intake: Total (g.)	Ca (mg./100 g.)	Total P (mg./100 g.)	Phytate-P (mg./100 g.)
Rye bread	520	42	296	61
Wheat bread	400	39	236	103
Rye vita	275	68	432	300
Porridge (oat)	2125	12	58	42
Panade (rye)	1650	13	39	9
Sauce	150	9	14	
Milk	2500	117	97	
Butter	225	21	15	
6 eggs	290	81	226	
Meat	200	20	194	
Meat balls	300	14	131	
Sausage	50	6	110	

Food	Intake: Total (g.)	Ca (mg./100 g.)	P (mg./100 g.)
Liver paste	125	9	140
Garfish	50	27	180
Rose-hip gruel	400	11	26
Fruit juice	500	6	5
Sago gruel	450	8	17
Apples	300	5	15
Potatoes	600	4	31
Peas	100	15	27
Carrots	200	30	44
Leeks	100	23	15
Cabbage	150	42	18
Jam	100	8	12
Water	1000	9	0

Table 3. *Retention of* Ca *and* P *from diets rich and poor in phytate*

Subject	Periods of 5 days: No.	Dates	Intake of: Ca (mg.)	Total P (mg.)	Phytate-P (mg.)	Excretion of: Ca in Urine (mg.)	Ca in Faeces (mg.)	P in Urine (mg.)	P in Faeces (mg.)	Phytate-P in faeces (mg.)	Retention of: Ca (mg.)	P (mg.)
M.H.J.	1	15. iii–20. iii	4,825	7,690	0	140	3,335	4,080	2,685	0	1,350	925
	2	24. iii–29. iii	4,531	7,472	70	144	3,525	4,455	2,115	0	862	902
	3	3. iv– 8. iv	4,415	7,525	40	112	3,270	4,015	2,280	0	1,033	1,230
	1+2+3		13,771	22,687	110	396	10,130	12,550	7,080	0	3,245	3,057
	4	10. iv–15. iv	4,730	10,396	2,596	122	5,020	4,230	4,285	1,025	−412	1,881
	5	17. iv–22. iv	4,575	9,860	2,215	134	4,085	5,310	3,125	765	356	1,425
	6	25. iv–30. iv	4,610	10,540	2,434	141	4,110	4,805	3,770	885	359	1,965
	4+5+6		13,915	30,796	7,245	397	13,215	14,345	11,180	2,675	303	5,271
	7	1. v–6. v	4,706	7,725	125	182	2,940	3,825	2,385	45	1,584	1,515
	8	8. v–13. v	4,485	7,560	0	126	3,340	3,535	3,165	0	1,019	860
	9	15. v–20. v	4,635	7,644	40	124	3,060	3,890	2,410	0	1,451	1,344
	7+8+9		13,826	22,929	165	432	9,340	11,250	7,960	45	4,054	3,719
J.T.	1	15. iii–20. iii	4,788	7,581	0	89	3,120	4,050	2,040	0	1,579	1,491
	2	24. iii–29. iii	4,494	7,398	65	93	3,400	2,785	2,655	80	1,001	1,958
	3	3. iv–8. iv	4,622	7,676	42	172	2,955	3,965	2,680	0	1,495	1,031
	1+2+3		13,904	22,655	107	354	9,475	10,800	7,375	80	4,075	4,480
	4	10. iv–15. iv	4,720	10,660	2,425	116	5,205	5,080	3,650	798	−601	1,930
	5	17. iv–22. iv	4,530	10,210	2,215	143	4,175	4,340	3,900	865	212	1,970
	6	25. iv–30. iv	4,615	10,300	2,430	102	4,385	4,525	4,125	716	128	1,650
	4+5+6		13,865	31,170	7,070	361	13,765	13,945	11,675	2,379	−261	5,550
	7	1. v–6. v	4,565	7,386	112	162	2,870	3,225	2,560	32	1,533	1,601
	8	8. v–13. v	4,430	7,410	0	98	2,545	3,060	3,005	0	1,787	1,345
	9	15. v–20. v	4,585	7,630	40	120	3,200	3,560	2,810	0	1,265	1,260
	7+8+9		13,580	22,426	152	380	8,615	9,845	8,375	32	4,585	4,206
	10	26. v–31. v	2,116	5,418	0	161	3,060	2,240	1,740	0	−1,005	1,438

RESULTS

The results of the experiments are given in Table 3.

DISCUSSION

Table 3 shows that calcium absorption was greatly reduced during the phytate periods. It is possible, however, that if the children had been kept on the diet rich in phytate for a longer period their calcium absorption might have gradually increased. Thus it is seen that the calcium absorption from a diet rich in phytate was considerably lower during the first 5 days' period than in the following periods. In both subjects, however, the increase in calcium absorption did not seem to continue beyond the second phytate period. Hence our results indicate

that in our subjects the 'adaptation' to conditions less favourable for calcium absorption was already complete after 7 days.

The composition of the calcium phytate precipitated in the intestine is probably $C_6H_8O_{24}P_6Ca_5$ (Hoff-Jørgensen, 1944) and therefore 1·0 g. of phytate-P should combine with 1·075 g. Ca to make the slightly soluble pentacalcium phytate. We therefore may estimate that in the phytate period 4 (subject J.T.) $2{\cdot}425 \times 1{\cdot}075 = 2{\cdot}61$ g. Ca was precipitated as calcium phytate and that $4{\cdot}720 - 2{\cdot}607 = 2{\cdot}013$ g. had not combined with phytate. In period 10 the intake of Ca from a phytate-free diet was 2·116 g. Therefore, if calcium phytate were completely unabsorbable we should have expected nearly the same calcium balance in period 10 as in period 4. The balance, however, was somewhat more positive in period 4; this indicates that a small part of the calcium which was precipitated as calcium phytate was absorbed.

Both the absorption and the retention of phosphorus were considerably greater on a diet rich in phytate than on a diet poor in phytate. The reason is presumably the same as that already considered in the discussion of the experiments with puppies (Hoff-Jørgensen, 1946).

The amount of phytate hydrolyzed in the intestines of the two children was about 70 % of that in the diet, and some of the split phosphate may have been absorbed.

SUMMARY

1. Two boys aged 10 years received during three periods of 5 days a diet poor in phytate. A diet rich in phytate was then given for three similar periods, and finally the first diet was again given. The diets contained 500 g. milk and about 0·9 g. Ca daily.

2. The effect of phytate was: (*a*) a great reduction in the absorption and retention of calcium; (*b*) an increase in the absorption and retention of phosphorus.

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Effects of Vitamin A Deficiency in the Rabbit

1. ON VITAMIN C METABOLISM. 2. ON POWER TO USE PREFORMED VITAMIN A

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The level of vitamin A in the blood and that of ascorbic acid in the aqueous humour of rabbits during vitamin A deficiency and cure have been investigated in connexion with detailed studies of the effect of vitamin A deficiency on the eye. Although they have been obtained with relatively few animals, the results are reported since the main experiment has now ended. They suggest two conclusions; first that the ascorbic acid of the aqueous humour is lowered by vitamin A deficiency and second that prolonged deficiency impairs either absorption and/or storage of vitamin A. This second conclusion is based on the fact that dosage with vitamin A in oil does not bring the blood vitamin A level back to normal. Subsequent feeding with cabbage will do so although the amount of carotene given is approximately equal to the amount of vitamin A fed previously.

EXPERIMENTAL

The rabbits used were of mixed Dutch stock. Either the young were put on the diet at weaning (5–6 weeks) or the nursing does were fed the deficient diet and this was continued to the young afterwards. In some cases the young rabbits were given a single dose of 1000 i.u. of vitamin A before being started on the diet in order to try to reduce the deaths among the young deficient animals and to obtain a gradual rather than an acute onset of deficiency. The effect of such a dose can be seen by comparing Figs. 1 and 2. The litter whose growth is shown in Fig. 2 was given a starting dose of vitamin A, while that shown in Fig. 1 was not. It can be seen that the fall in growth rate due to deficiency occurs some months earlier in litter 1 (rabbits 40, 41) than in litter 2 (rabbits 50, 51).

Diet. A diet of crushed oats plus 1·5 % of powdered chalk mixed and made just damp with water was fed *ad libitum*. The chalk was added to bring the calcium: phosphorus ratio of the oats near unity to diminish the need for vitamin D.