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THE UTILIZATION OF THE PHOSPHORUS FROM AN ALUMINIUM-IRON ROCK PHOSPHATE. I. BY THE RAT.

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Due to the wide-spread deficiency of phosphorus in our natural pastures, supplementation of this mineral, in one form or another, will always play an important role in successful stock raising in this country. Unfortunately, local production of bone meal and other phosphatic products cannot at present meet an increasing demand for these commodities. To cope with the shortage, import and a search for other mineral supplements which would be satisfactory sources of phosphorus for animal feeding, are resorted to.

Some time ago a new deposit of natural rock phosphate was discovered in the Middelburg district, Transvaal. This mineral had an advantage over other rock phosphates, in that it contained a negligible amount of fluorine and could therefore be fed to animals without prior defluorination. On the other hand, high percentages of iron and aluminium cast considerable doubt on the efficiency of the deposit as a source of phosphorus in animal nutrition. Determined attempts were nevertheless made by interested parties to obtain official sanction for marketing the product.

It was, therefore, decided to conduct biological tests on the product, using both rats and sheep as experimental animals, despite the evidence in the literature relating to the low availibility of iron and aluminium phosphates [Theiler, Viljoen, Green, du Toit and Robinson (1927); Cox, Dodds, Wigman and Murphy (1931); Deobald and Elvehjem (1935); Jones (1938); Rehm and Winters (1940), and Street (1942)]. This paper reports the results of the experiment on rats.

EXPERIMENTAL.

Two samples of the rock phosphate, with compositions as set out in Table 1, were compared with dicalcium phosphate at a level which furnished 0·16 per cent phosphorus to the diet. For this purpose, a basal ration, containing 0·05 per cent phosphorus, was supplemented with the appropriate amounts of the phosphatic products to yield diets A, B and C (c.f. Table 2). Calcium carbonate was added to ensure a Ca:P ratio of more or less 2:1.

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TABLE 1.

Composition of the Rock Phosphates.

Sample.	% P.	% Al_2O_3.	% Fe_2O_3.
Untreated B	13·4	15·3	15·5
Treated C	16·4	29·4	17·3

TABLE 2.

Composition of Diets.

Ingredients.	Diet A.	Diet B.	Diet C.
Egg white	150	150	150
Gelatine	30	30	30
Butterfat	80	80	80
Bacto agar	20	20	20
Harris yeast	15	15	15
Cod liver oil	20	20	20
Sucrose	40	40	40
Salt mixture*	30	30	30
Dextrinized starch	606·9	601·1	602·4
Dicalcium phosphate	4·2	—	—
Untreated rock phosphate	—	7·0	—
Treated rock phosphate	—	—	5·7
Calcium carbonate	3·9	6·9	6·9
TOTAL	1,000	1,000	1,000
Per cent P	0·17	0·17	0·17
Per cent Ca	0·34	0·33	0·31

* Day and McCollum (1939), with calcium carbonate omitted.

Eight quartos of albino rats of the same age, sex and weight were selected. To arrive at values for the phosphorus content of the rats at the commencement of the experiment, one member of each quarto was sacrificed and analysed as described by Reinach and Louw (1950). The remaining trios were distributed among the three diets described in Table 2 giving 8 rats per group. The rats were fed daily, the feed intake being equalized within each trio to that of the animal consuming the least. They were weighed weekly and provided with fresh distilled water at all times. At the end of the experimental period, which lasted six weeks, they were killed with ether and analysed.

Growth, femur ash and total phosphorus retention were used as criteria for evaluating the availability of the phosphorus in the rock phosphate.

Results and Discussion.

The group averages for growth and metabolism of the rats on the three different diets are given in Table 3.

The group of rats receiving dicalcium phosphate in their ration doubled their weights within six weeks, while the other two groups receiving the rock phosphate, showed an increase of only 78 per cent over the same period. Statistically this difference was highly significant at $P = 0{\cdot}01$ with a coefficient of variation of 8·7 per cent. Since both the phosphorus content of the ration and the level of feed intake were equalized in the three groups, the poorer growth, shown by the rats receiving the rock phosphate, must be ascribed to the poorer utilization of the phosphorus in that product.

Further evidence of the poor utilization of the phosphorus in the rock phosphate was obtained from the data for total and percentage ash in the femurs of the rats. The rats fed the dicalcium phosphate developed larger bones than those receiving the rock phosphate. The average values for total ash of the femurs were 0·075 gm. for group A and 0·034 gm. for both rock phosphate groups. This difference was found to be highly significant at $P = 0{\cdot}01$ with a coefficient of variation of 9·7 per cent. The degree of mineralization was also found to be significantly in favour of the group of rats receiving the dicalcium phosphate. This group showed a percentage ash of the femur on the dry fat-free basis of 49·7 as against 35·0 and 34·4 for the two rock phosphate groups respectively. These results correspond with those obtained for the retention of phosphorus.

The percentage retention of the phosphorus was based on the assumption that all groups initially contained equal amounts of calcium and phosphorus. This amount of calcium and phosphorus was obtained from the analysis of the rats sacrificed at the commencement of the experiment.

The figures for the percentage retention of phosphorus, as calculated from the available data, were 53·3 for the dicalcium phosphate group as against 15·0 and 14·1 for the two groups receiving the rock phosphate. The difference in favour of the first-mentioned group was significant at $P = 0{\cdot}01$ with a coefficient of variation of 15·1 per cent. Since the phosphorus content and level of intake were the same for the three diets, the differences in the retention figures for phosphorus can only be attributed to differences in the availability of this mineral in the diets. The two samples of rock phosphate thus appear to be a very poor source of phosphorus for the growing rat and cannot be recommended as a substitute for bone meal or other phosphatic products in the rations of animals.

Summary.

The availability of the phosphorus in two samples of an aluminium—iron rock phosphate has been determined in the rat. In evaluating these products live weight gains, the ash content of the femurs and total phosphorus retention have been used as criteria. The rock phosphate was found to be a poor source of phosphorus.

TABLE 3.

Mean Growth and Metabolism Data of Rats on different Diets.*

	Initial Wt. (gm.).	Total Gain (gm.).	Wt. Femur Ash (mg.).	% Ash in Dry Fat-free Femur.	Ca Intake (mg.).	Ca Retained (mg.).	% Ca Retained.	P Intake (mg.).	P Retained (mg.).	% P Retained.
Diet A.....	58	58	75·3	49·7	895	329	37·0	448	239	53·3
Diet B.....	59	46	34·0	35·0	862	24·1	2·8	452	68·5	15·0
Diet C.....	59	46	34·5	34·4	818	19·8	2·7	456	64·8	14·1

* Eight animals were used in each group.

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