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SIGNIFICANCE OF MINERAL METABOLISM

I. PRELIMINARY REPORT ON THE CALCIUM AND PHOSPHORUS CONTENT OF SOME PORTO RICAN FOOD MATERIALS

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The significance of calcium and phosphorus in animal nutrition has been evident since the knowledge of the composition of the skeletal frame work of mammals was recognized. As our knowledge of plant and animal life has increased, more and more elements, other than carbon, hydrogen, oxygen, nitrogen and sulphur have been added to the list as being essential to life and normal development. Sodium, potassium, iron, magnesium and iodine have long been known as necessary constituents of blood, bone and specialized organs but we can not say that the fifteen or sixteen elements now recognized as occurring in the body complete the list, nor do we know as yet all the ways in which these elements may function.

The whole problem of mineral metabolism is a very complicated one. We are learning new facts concerning the action of known elements and are finding that perhaps traces of new elements may play important roles in disease. This is witnessed by the discovery last year that copper may be associated in some way with the formation of hemoglobin and thus may have a bearing upon the treatment of certain types of anemia.

Mineral elements play a very definite role in muscle tone, rhythmic contraction and nervous irritability. Aside from those important and those of osmotic pressure, membrane potential, etc., it is known that the activity of enzymes *in vitro*, and very probably also *in vivo*, depend on the presence of certain salts. The acid-base mechanism, that delicate balance whereby the blood and body fluids are maintained during health at a definite degree of alkalinity or acidity,

depends in part on mineral salts. We have long known that the iron of the hemoglobin molecule functions in some way as an oxygen carrier and evidence is accumulating that other metals may assist in oxidation-reduction processes in the body. These latter are perhaps among the most important of all classes of bodily processes, for after all the animal body obtains its energy through the oxidation of food, and it may well be that the failure of our food to supply some known or unknown element may mean the difference between health and disease.

Certain observations in the course of nutrition studies here in Porto Rico led us to formulate a definite plan of investigation of the question of mineral metabolism. Some of the phenomena noted, for example, the frequency of carious teeth, pointed to nutritional disturbance during growth. Others, such as the "dirt-eating habit" among dairy cattle, were considered to be evidence of a lack of calcium or phosphorus, or both, in the grasses of Porto Rico. It is well known that dairy cattle are often in negative calcium balance; that is, they are excreting through the milk, urine, and feces a greater quantity of calcium and phosphorus than they are receiving in the food. Yet the quantity of these elements in the milk may not vary to any great extent, the necessary amounts to make up deficiencies in the diet being withdrawn from the relatively large store in the bones. This is also true in the human species. In the process of growth a great demand is placed on the calcium and phosphorus supply to furnish material for new bone formation. The mother during pregnancy needs an extra supply, and in lactation the drain on her own bony structure may be very great, leading to a deficiency if the diet is inadequate as respects these mineral elements.

The calcium requirements for the adult has been fixed by experiment at 0.45 gm. per day, but Sherman points out that this figure "approximates the minimum of actual need rather than a normal allowance". For growing children he finds that at least 1 gm. per day seems to be necessary for the most efficient utilization, and he recommends this as the normal allowance for children and adults. The phosphorus minimum has been established in like manner at 0.88 gm. with the normal allowance at about 1.5 gm. per day. He goes on to state that "the injurious effect of insufficient intake of calcium is of course more noticeable with growing than with full grown animals". No data are available as to the effects on the adult of a long continued low calcium intake, other than the weaken-

ing of the bones by metabolic demands when the requirement is not furnished in the food. Some medical writers have attributed various diseases, in addition to rickets, to a lack of calcium or a disturbance of calcium metabolism. But further research will be required before definite evidence of such etiological relationship can be offered. It must be remembered that though the Rickets Commission in 1927 found only one case of active rickets among seven hundred children examined in Porto Rico, this does not mean that the diet consumed here is adequate to prevent the disease. Sherman says: "It has been fully demonstrated, especially in well-controlled laboratory experiments on rats, that rickets may be induced or prevented at will in any of three ways, the experimental conditions being suitably chosen in each case: (*a*) By changes in the amounts and proportions of calcium and phosphorus supplied through the blood, (*b*) by the deficiency or the abundance of the anti-rachitic vitamin, (*c*) by the deficiency or adequacy of the ultraviolet irradiation received (usually) either as direct sunlight or from a quartz mercury vapor lamp". There is good evidence that diets among the poor in Porto Rico are deficient in either mineral salts or vitamins and it is only due to the exposure of the young children to the wealth of healing sunlight that prevents the appearance of rickets here. Herter believes that many cases of arrested development may be due to insufficient assimilation of calcium from the food. There is very definite evidence that the feeding of bone meal to cattle raises the calcium-phosphorus of the blood and may increase the quantities excreted in the milk. Dairy stock here in Porto Rico have shown an increase in the calcium of the milk from 0.11 per cent, when on the ordinery grass and grain ration, to 0.14 per cent after the addition of bone meal.

A recent study of the food imports revealed the significant fact that Porto Rico is importing some seventy-five per cent of its basal energy requirement, or fifty per cent of the energy required to furnish an adequate diet of 2,800 calories daily per capita. As pointed out in this article, a food must not only furnish energy but must supply other equally important nutritional factors, among which are mineral elements, particularly calcium and phosphorus. In order to see if Porto Rico was obtaining an adequate supply of the necessary minerals the calcium and phosphorus content of the imports for 1926 were calculated, using the ash analysis of common foods published in Sherman's "Chemistry of Food and Nutrition". The

results are shown in Table I. The figures under "daily intake" are Sherman's minimum and normal requirements.

TABLE I

Daily intake	Porto Rico's yearly requirement. Population: 1,417,000	Amount furnished by imports (1926)	Proportion of requirement furnished by imports
Calcium 0.45–1.0 gm.	226–503,000 kilos	72,000 kilos	14–32 per cent
Phosphorus 0.88–1.5 gm.	443–754,000 kilos	303,000 kilos	40–71 per cent

From this it is seen that the imports instead of furnishing fifty to seventy-five per cent of the calcium requirement, in line with the energy that they furnish, are supplying but fourteen to thirty-two per cent. This leads to the conclusion that unless this deficiency can be made up from foods produced in the island, a definite calcium shortage exists. It will be noticed that the import figures for phosphorus are proportionately much higher, and it may be assumed that there is no serious shortage here of this element.

For a supply of calcium in locally produced foods we look first to milk since its content of calcium is known to be high, but when we consult the statistics of the Department of Health we find that in April of this year (1928) published figures show that the milk production of Porto Rico, is about 33 gm. per person per day. This is much too small an amount to serve as a source of calcium supply. It must be remembered that only about fifty per cent of the energy requirements are supplied by local foods, whereas the same foods must supply eighty-five per cent of the calcium. Of the commoner foods milk, meat and eggs are the richest in mineral salts, particularly calcium. However, in Porto Rico these foods enter but slightly in the dietary of the masses, whose calcium needs must be met from their staple foods, which are root vegetables, bananas and plantains. With the important exceptions of carrots and turnips, root crops are generally low in calcium. Bananas also contain very little, as does also polished rice, which forms such a large part of the diet. Indeed we believe it is because of the predominant place of rice in the Porto Rican diet that the calcium supply is so low. The analysis of Porto Rico plant foods for calcium and phosphorus is incomplete but the results so far obtained do not remove our early suspicions that a serious calcium shortage exists here.

TABLE II

Ash Constituents of Food in Percentage of the Edible Portion

Food	Calcium	Phosphorus
Breadfruit	0.017	
Gandules (1)	0.041	
White yautía (2)	0.004	0.36
Yellow yautía (3)	0.014	0.41
Banana	0.009	0.031
Breadfruit	0.084	0.086
Kindney beans	0.132	0.475
Cheese	0.931	0.683
Fish	0.022	0.23
Grapefruit	0.021	0.02
Mamey	0.009	0.028
Mango	0.021	0.017
Milk, fresh	0.12	0.093
Oranges	0.045	0.021
Rice, white	0.009	0.096
Turnips	0.064	0.046
Meat	0.012	0.216

NOTE: The above analyses are taken from Sherman's "Chemistry of Food and Nutrition", except in the cases of breadfruit, gandules, white and yellow *yautía*, which were analyzed in our laboratory.

From the above table it is seen that of the Porto Rican foods so far analyzed there are none comparable to milk, beans or cheese in calcium content. It is doubtful if further studies will bring to light any native fruit or vegetable sufficiently rich in calcium to meet the existing deficiency.

(1) Cajan Cajan, a tropical bean.
(2) Xanthosoma caracu, a potato-like vegetable.
(3) Xanthosoma sagittoefolium, a potato-like vegetable.