RICE AND BEANS AS AN ADEQUATE DIET

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From the study of the food imports of Porto Rico we find that rice and beans make up about fifty per cent of the total energy of imports.(1) This fact has led us to study the adequacy of a rice-bean diet to support growth in the rat.

A preliminary report on the growth curves of rats receiving a standard laboratory diet compared to that produced by feeding rice and beans alone was published last fall.(2) The experiments were incomplete at that time and it is now possible to present further information on the qualities of the above diet.

To be adequate for the demands of normal life, a food must perform four functions:

1. It must furnish sufficient energy.
2. Furnish sufficient protein of the right kind.
3. Provide an adequate supply of all the mineral elements required by the organism.
4. Furnish sufficient amounts of all the vitamins.

In how far can the rice-bean diet qualify for these four requirements? Of course in this case No. 1 can be eliminated since the animals were fed *ad libitum*. The protein of rice is low and apt to be deficient in some of the essential amino acids required for tissue building, when the hulled or polished variety is used, as is the case here. Hopkins(3) states " . . . Rice may serve the races which rely upon it as an almost exclusive source of protein, while wheat is only suitable for races that take a much more varied dietary." McCollum and Simmonds(4) believe that "Rice proteins like those of maize and wheat are of relatively low biological value. Osborn and Mendel (5) state that the proteins of brown rice are adequate for nutrition in growth but that hulled rice might be deficient. Navy bean protein is adequate for growth provided the amino acid cystine is added.(6-7) No direct reference has been found to the adequacy of kidney bean protein but it is quite probable that this latter would be deficient in the same amino acids. With this knowledge of the quality of the proteins of rice and beans it is possible the mixture of the two would be deficient in its protein supply, either due to the low intake of protein or its quality.

Approximately 60 per cent by weight of boiled rice and 40 per cent by weight of boiled beans were fed in these experiments. The ash analyses of this diet is approximately:

0.018 per cent Ca.
0.074 per cent P.

While the standard laboratory diet runs about:

0.35 per cent Ca.
0.50 per cent P.

or 20 times as much Ca. and 7 times as much P.

This is a point to consider in the growth of the skeleton and would lead us to suspect that the diet might fail from the mineral standpoint, either because of a lack of calcium or because the ratio of calcium to phosphorus is abnormal. Sherman and Pappenheimer([8]) have shown that it is possible to cause rickets by lack of phosphorus in the diet and cure the animals by the addition of sodium phosphate. Sherman([9]) states, "Rickets can be produced experimentally by diets of faulty mineral content; but usually only when there is also a relative deficiency of the regulating factors-antirachitic vitamin and ultra violet light."

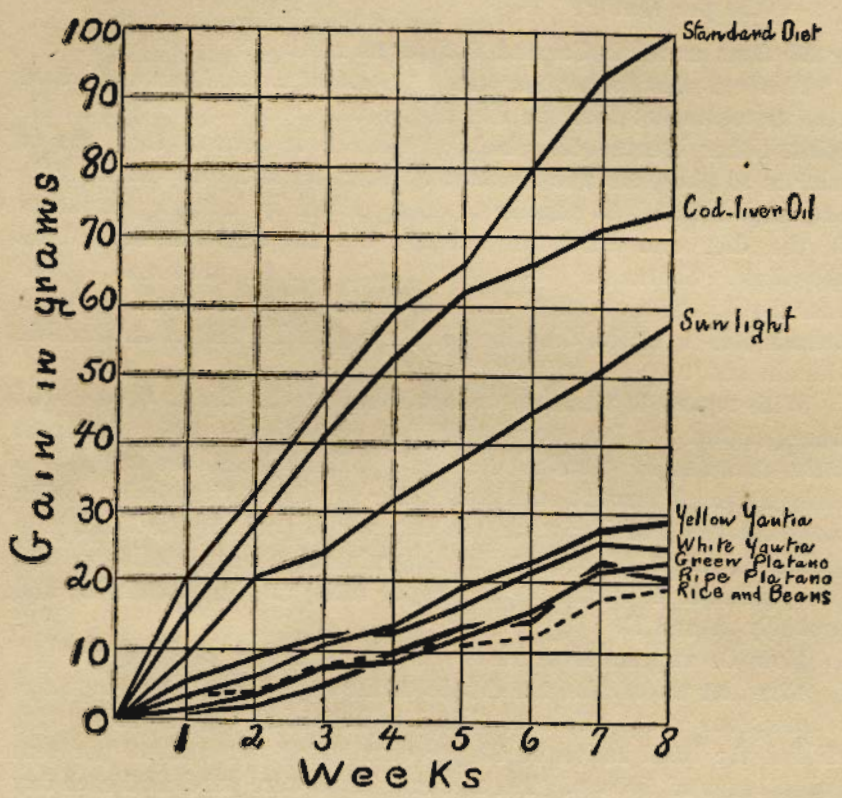
With regard to vitamins we would expect the diet to be deficient since polished rice has proved to be low or lacking in the antineuritic factor and also in vitamins A and D. Kidney beans are believed to contain a small amount of A and a fair supply of vitamin B. From the theoretical considerations the diet would probably be lacking in kind or amount of protein, in the mineral elements calcium and phosphorus or at least in their proper ratio, and in vitamin D, and probably A and B.

How do experimental results check with this prophecy?

First, let us examine the details of the experiment. Seven groups of rats, four weeks old, were placed in individual cages. These were all fed the basal ration of 60 per cent boiled rice and 40 per cent boiled beans *ad libitum*. The rice and beans were purchased each day from a *restaurant* in Puerta de Tierra as it was felt that in this manner conditions met with in the country districts could be more nearly duplicated than by cooking the foods in the laboratory. The stewed beans always contain small amounts of other vegetables as is customary in Porto Rico, and though these add both vitamins and mineral salts, still that is the way people prepare the food and the experiment was designed to test the food under living conditions as they exist here. One of the seven groups of animals received no further supplements or treatments and became the control group.

Later in the preliminary work we discovered that not only did the animals fail to grow well but it was noticed that all rats on this diet developed definite symptoms of rickets, having an overgrowth of osteoid tissue at the ends of the long bones and showing characteristic beading of the rib junctions.

This fact led to a trial of cod-liver oil and sunlight on two groups of animals, as supplements to the basal ration of rice and beans. The first group received four drops daily of cod-liver oil



and the other group was placed in sunshine for two hours daily from 11:00 A. M. to 1:00 P. M. when the sun was nearest the verticle. Neither of these two groups developed rickets and they grew at much greater rates than those who did not receive this treatment. It is thus probable that vitamin D is the first limiting factor in the diet.

Wishing to find some home-grown fruit or vegetable that might supplement and enrich the rice-and-bean ration the following experiment was tried.

One of the remaining four groups of animals was placed on the basal ration of rice and beans plus 20 per cent by weight of boiled white *yautía*. Another received 20 per cent boiled yellow *yautía* and a third received 20 per cent boiled green *plátano* and the fourth 20 per cent boiled ripe *plátano*.

The chart shows the curves of growth of the seven groups of experimental animals compared to a group on an adequate diet. It can be seen from this that the cod-liver-oil group grew almost at the same rate as the normal animals, while the sunlight group grew at about half rate. This is interpreted as due to the fact that the cod-liver oil contained vitamin A also, since the effect of sunlight is as far as we know simply to activate certain sterols in the skin to produce vitamin D. Therefore, the superior growth of the cod-liver oil group can only be attributed to the presence of some other factor than vitamin D which is in this case most probably vitamin A. Thus the first limiting factor in the deficient rice and bean diet is the antirachitic vitamin D, then vitamin A.

The white and yellow *yautía* curves show slight improvement over those of *plátano*. But since the actual food intake was very nearly the same in each case the slightly better growth is very probably due to the actual difference in Vitamin D content and not to variations in the animals. The groups on *yautía* and ripe *plátano* show no definite evidences of rickets on gross examination.

The microscopic examination of the rib sections reveals the fact that the yellow *yautía* and ripe *plátano* exert a slight preventive effect in spite of the fact that the animals on these supplemenary diets grew more than on the rice and beans alone; still the examination shows three normal and three slight rickets among these groups. The white *yautía* group had more marked rickets than any other, probably because they made better gains and there was too little vitamin D to be effective in preventing the onset of the disease. The better growth in these four groups over that made by the rice-and-beans group is not attributable to greater food intake, since in the case of the last four groups on the chart the food intake per animal per week is approximately the same, being 134 gr. for the yellow *yautía*, 135 gr. for the white *yautía*, 128 gr. for the ripe *plátano*, 127 gr. for the green *plátano*, while the rice-and-beans group consumed 105 gr. per animal per week.

It is to be remembered that rickets becomes most prominent during rapid growth and may not be grossly evident in those animals that have failed to make good gains in weight. In the control group, however, the almost entire lack of the vitamin caused sufficient change

in the bones to be evident on autopsy. Evidently neither the *yautías* nor the ripe or green *plátano* can be considered as adequate supplements of the deficiencies of rice and beans unless some other food containing vitamin D is added to the diet, or sunlight is allowed to act on the individual.

BIBLIOGRAPHY

(1) Cook, D. H.: (1927) P. R. Review of Pub. Health & Trop. Med., **3**: 59.
(2) Cook, D. H., Rivera, Trinita: (1927) Ibid, **4**: 253.
(3) Hopkins, F. G.: (1917) Analyst, **31**: 395.
(4) McCollum, E. V. and Simmonds, N. G.: (1917) J. Biol, Chem., **32**: 361.
(5) Osborn, T. B. and Mendel, L. B.: (1919) J. Biol. Chem., **34**: 521.
(6) McCollum, E. V., Simmonds, N. G. and Pitz, W.: (1917) J. Biol. Chem., **29**: 521.
(7) Johns, C. O. and Fink, A. J.: (1921) J. Biol. Chem., **34**: 189.
(8) Sherman, H. C. and Pappenheimer, A. W.: (1921) J. Biol. Chem., **34**: 189.
(9) Sherman. H. C.: Chemistry of Food and Nutrition, 3rd. ed., pp. 477.