NOTE ON THE EFFECT OF FEEDING RAW AND COOKED TUBERS

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The following investigation was initiated by the appearance of an article concerning the defective nature of the tuber tannia when fed as the sole article of diet.

Clark(1) found that the tannia (Calacasia macrorrhiza) of Trinidad produced death in an average of eight days when fed raw, but that the animals lived for some time on the boiled plant. From the symptoms and autopsy findings he concluded that the death of his animals might be due to the presence of an irritant poison such as saponin.

Since the related species malanga (Caladium calacasia) and the yautias (Xanthosoma caracu, xanthosoma hastatum) are used here in Porto Rico to a large extent it would be of interest to determine what, if any, would be their physiological effect.

EXPERIMENTAL

Albino rats four to six weeks old were taken from an adequate diet and placed on raw malanga as the sole source of food. Another group was fed boiled malanga. On the chance that the water used in boiling dissolved some of the toxic principle, a third group was fed malanga which had been cooked by means of steam.

A fourth and fifth group were placed on raw white potato and raw white yautia as control groups.

The results are expressed in the following table:

Table I

Food	Ave. amount eaten per day	Survival period	Remarks
Raw malanga	10 grams	8.5 days	
Raw potato	8 "	8.0 "	
Raw yautia	8 "	12.0 "	
Boiled malanga	40 "	180.0 "	Killed at 180 days
Steamed malanga	40 "	180 "	" " " "

During the progress of the experiment a paper by Seager(2) appeared in which he seems to have anticipated our work; using even more plants than we had included. We quote from his paper the following results (See Table II):

TABLE II

	Days
Boiled tannia	101
Unboiled tannia	31
Boiled dasheen	136
Boiled yam	64
Unboiled yam	18
Boiled potato	28
Unboiled potato	15
Tannia water	8
Yam water	8
Potato water	3
Water only	3
Boiled brown rice	94

As will be noticed from this table the author speaks of using "Water decoctions of the various tubers." We understand this to mean "with heat" and therefore we determined to test the raw juice of the malanga for toxic effects. Since at the time of this experiment no laboratory press was available, the root was grated and 100 cc of distilled water was mixed with each 100 grams of grated root and allowed to stand for thirty minutes, with occasional stirring. The whole mass was then pressed through coarse cheesecloth and the thick, ropy milk-white juice was fed.

One group of animals was placed on the standard laboratory diet (Sherman's diet 13) with the expressed juice in place of the usual water. A second group was fed boiled malanga and juice. Since the boiled root contains much water which might suffice for the needs of the animals, the prepared root was dried and then ground to a coarse powder and the juice fed in cups as in the first group.

A third group was fed juice only and a control group was given only water. The results are shown in Table III.

TABLE III

Food	Ave. amount eaten per day	Survival period	Remarks
Diet 13 and malanga juice	10-15 and 5-6 cc.	Over 100 days	Growing normally
Dried boiled malanga and juice	3.5 g. and 5-6 cc.	42 days	Symptoms of B. deficiency
Dried boiled malanga and water	3.5 g.	50 days	Symptoms of B deficiency
Malanga juice	7-8 cc.	7 days	
Water alone	7-8 cc.	7 days	

Since the appearance of the feces in some of the groups showed a possible tendency to constipation a further test was made by mix-

ing ground agar-agar with the raw foods to the extent of two per cent. These results are given below:

TABLE IV

Food	Ave. amount eaten per day	Survival period
Raw malanga, 2 per cent agar..	8.....	7 days.....
Raw white potato 2 per cent agra.....	13.....	11 days.....
Raw white yautia 2 per cent agar.....	6.....	12 days.....

DISCUSSION

Clark speaks of the intense intestinal irritation and hemolysis in the liver and spleen of his animals, together with distension of the caecum. We have been able to corroborate these findings, though pathological examination of the liver, kidney and spleen shows no characteristic lesions. The state of the intestinal tract, however, does not, in our opinion, warrant the definite conclusion of an irritant poison since we found in the case of the raw white potatoes an identical picture. The conclusions as to the toxicity of the saponins are not very definite though the general opinion is that they are much less toxic by mouth than when injected intravenously. Kopter and Schurtke([3]) indicate that the lethal oral dose can be 3–300 times that of intravenous, while Wacker([4]) fed dogs 0.5 grams saponin per day for thirty-two days without causing death, though on autopsy there was fatty degeneration of the kidneys.

The distension of the caecum commented on by Clark can be explained on the basis of the volume of raw food eaten.

Seager suggests a generalized protein and Vitamin A deficiency. This latter deficiency may have been the case in his experiments with wild rats but could not have occurred in the majority of our animals. Sherman and Kramer([5]) have studied the capacity of the rat to store Vitamin A when fed varying amounts and rats taken from Diet 13 and placed on an A-free diet live for an average of from fifty to sixty days. Since many of our animals died within two weeks or else lived to six months or more, Vitamin A could not be the first limiting factor, at least in the early deaths. Protein starvation may have played a role in those animals on the boiled dried malanga, since Hartwell([6]) has shown that the potato as the sole source of protein is insufficient to support growth or maintain life, and since the malanga has about the same percentage of protein we would not expect it to suffice either. But again, protein starvation would not

show up as the cause of death as soon, as indicated by the experiments with raw tubers.

Since some of the animals on raw malanga lived no longer than in complete starvation (water alone) we might conclude that there was a toxic principle present since the starch of the malanga eaten should have helped sustain life for a time. But if that is true why do the animals on Diet 13 and malanga juice, or those on dried boiled malanga and juice continue to live, since the juice as expressed must contain any toxic material originally present?

It might be argued that the indigestibility of the raw root is the reason for this. But the rat is an omnivorous animal accustomed to taking food raw, and furthermore Langworth and Merril([7]) have shown the raw potato to be reasonably digestible even in the human. Galamini([8]) found that rats fed raw or cooked white potato did not grow; those on raw, losing weight more rapidly. But in the reference available there is no conclusion drawn. We cannot conclude that failure to live or even grow is due in this case to digestibility alone.

There was indication in the animals on boiled dried malanga of Vitamin B deficiency as might be suspected, as the root is not a very good source of this factor and in boiling and drying there was no attempt made to prevent oxidation. But this does not explain the difference that exists between the raw and cooked plant. Attempts to isolate a saponin by standard methods and testing against washed red cells failed, corroborating Seager's findings. We are unable to draw any definite conclusions from the work in its present state.

It would appear from Clark's, Seager's and our work that cooking does definitely improve the nutritive value of raw tubers. This can not be because of improvement of the protein by heat as indicated by Galamini's work. Nor can it be due to the presence of a toxic material such as the saponins since they are uneffected by heat. It is probable that the digestibility has been improved by cooking but it is difficult to believe that this is the sole factor. The food records indicate the possibility of starvation playing a role. While those animals on boiled and strained malanga ate an average of forty grams per day those on the raw ate but ten grams or less. Since the raw contains some seventy-five per. cent water this means that they were only eating two to three grams of solids while in the case of the boiled malanga the intake was from eight to twelve grams and this certainly would influence the length of life.

Few natural foods are complete in themselves. Root crops are

generally lacking in fat and are low in protein. They are apt to be deficient in one or more vitamins and in mineral salts, and the failure of animals to grow or live when fed on such articles of diet is therefore difficult to interpret as the results are due to a combination of deficiencies.

Seager points out that the final test in a study of this nature lies in proving whether the article is harmful or not when fed with a properly balanced food. The results with a standard diet and malanga juice indicate nothing of a very toxic nature.

It is evident that no really valid conclusion can be drawn in the present state of the investigation and further work will be necessary to elucidate the apparent anomalies.

BIBLIOGRAPHY

1. Clark, A.: (1929) Trans. of the Royal Soc. of Trop. Med. & Hyg., **23**: 167
2. Seager, E. A.: (1930) Trop. Agriculture, **7**: 120
3. Kofler, L. and Schurtke, W.: (1926) C. A. **20**: 2202
4. Wacker, L.: (1909) C. A., **3**: 1919
5. Sherman, H. C. and Kramer, M.: (1924) Jour. Am. Chem. Soc., **46**: 1055
6. Hartwell, G. A.: (1927) C. A., **21**: 2295
7. Langsworth, C. F. and Merill, A.: (1924) C. A., **18**: 2391
8. Galamini, A.: (1928) C. A., **22**: 4154