

**A NOTE ON THE PRESENCE OF NORADRENALINE AND
5-HYDROXYTRYPTAMINE IN PLANTAIN
(*MUSA SAPIENTUM*, VAR. *PARADISIACA*)**

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Received February 2, 1960

Noradrenaline, 5-hydroxytryptamine and dopamine are present in the fruit of *Musa sapientum*, var. *paradisiaca* (Plantain), which forms a staple food of many inhabitants of West Africa. The amounts of 5-hydroxytryptamine and noradrenaline are highest when the fruit is ripe. An estimated daily intake of 10 mg. of 5-hydroxytryptamine by West Africans has little apparent effect on the normal functioning of the intestinal tract.

THERE has been correspondence in the literature on the presence of biologically active substances in edible fruits, notably tomato^{1,2} and banana¹. The banana-like fruit known as plantain, a staple food of many West Africans, has been examined for the presence of catechol amines and indole derivatives, especially 5-hydroxytryptamine (5-HT). Parts of the plant also were examined in various stages of growth to study the functions and biosynthesis of the amines in nature. When these experiments were nearing completion a brief report on the presence of catechol amines and tryptamines in the "matoke" banana was published by Marshall³. In samples obtained from East Africa he showed that both noradrenaline and 5-HT are present in the peel and pulp of the fruit of the "matoke" in amounts similar to those found in the common banana. Botanically both "matoke" banana and plantain are *Musa sapientum* var. *paradisiaca*, though in West Africa several varieties of plantain are under cultivation. As the possibility arises that the time taken for the transport to England of bananas and "matoke" bananas affects the amounts of amines present, we used only fresh material obtained from locally grown plants.

METHODS

Extraction and Estimation of 5-Hydroxytryptamine

The plant tissues were cut into small pieces and extracted with 5 parts (w/v) of acetone for 24 hours. The solvent was then decanted and the residue washed with a little acetone. The acetone in the combined extracts was removed by evaporation in air at room temperature (25° to 29°). The dried extracts retained their activity for some days when stored at 0°. When required for biological assay the extract was dissolved in 0.9 per cent (w/v) saline to give a solution of 1 g. of original material in 50 ml.

These solutions were assayed on the isolated uterus of the rat in oestrus or the rat isolated colon, or both preparations, using an aerated 10 ml. bath of Jalon's fluid containing atropine (10^{-7}) at 28° for the uterus and at 25° for the colon. The standard 5-HT was used as the creatinine sulphate, and specificity of action was checked using bromolysergic acid diethylamide (brom-LSD).

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Extraction and Estimation of Catechol Amines

Small pieces of tissue were extracted with 0.1 N hydrochloric acid for 24 hours. The samples were then assayed for noradrenaline on the rat blood pressure. Rats were anaesthetised with urethane, 0.75 ml. of 25 per cent solution subcutaneously, and the blood pressure recorded from the right carotid artery using a Condon manometer. Brom-LSD, 1 mg./kg., was injected intravenously to abolish the effect of 5-HT, which is also extracted by the hydrochloric acid.

Paper Chromatography

Extracts made with acetone or 0.1 N hydrochloric acid were chromatographed on Whatman No. 1 paper using as solvent systems: (i) 8 per cent sodium chloride in distilled water⁴; (ii) butanol-acetic acid-water mixture (4:1:5); (iii) phenol saturated with water and sulphur dioxide⁵.

With systems (i) and (ii) ascending chromatograms were run for 4 and 16 hours respectively in an air conditioned room at 21°. Chromatograms using system (iii) were run for 24 hours at 26.5° to 27.5°. System (iii) separated noradrenaline (R_f value 0.39) from adrenaline (R_f value 0.61) and dopamine (R_f value 0.54). The spray developers used were 1 per cent potassium iodate or 0.44 per cent potassium ferricyanide in a phosphate buffer of pH 7.8 for catechol amines and Ehrlich's reagent for indoles.

RESULTS

Estimation of 5-Hydroxytryptamine

Plantain fruits, in various stages of ripening, were obtained from trees surrounding the College compound or from local traders. After extraction, the 5-HT content was estimated. The results are shown in Table I. These values should be compared with those obtained for two very small

TABLE I
5-HT CONTENT ($\mu\text{G./G.}$, CALCULATED AS BASE) OF PARTS OF THE PLANTAIN FRUIT AT DIFFERENT STAGES OF MATURITY

Stage	Part of fruit	Individual results					Mean
Unripe	Skin	28.8	10.9	6.5	21.1	20.8	17.6
	Pulp	59	54.5	24	74	38.2	49.9
Ripe	Skin	—	32.7	17.7	—	73.4	41.3
	Pulp	52.5	52	39.2	39.2	101	56.7
Over-ripe	Skin	6.5	4.8	—	—	—	5.6
	Pulp	11	13	—	—	—	12

fruits (pulp and skin combined) of 2.6 and 11 $\mu\text{g./g.}$ It is apparent that the amount of 5-HT in both pulp and skin increases during ripening. In another experiment a bunch of unripe fruits was cut from a tree and left to ripen in the laboratory. Every few days a fruit was removed and its 5-HT content estimated. The results (Table II) again indicate that

during the ripening process the content of 5-HT in both pulp and skin increases.

Smaller amounts of 5-HT are present in other parts of the plant. Thus only traces were detected in leaf and stem (0.12 to 0.5 $\mu\text{g./g.}$) and slightly more in buds (0.26 to 3.3 $\mu\text{g./g.}$) and flowers (1.3 $\mu\text{g./g.}$).

Plantains are nearly always eaten after being cooked, either boiled, or, more often, fried in groundnut oil. It was important therefore to deter-

TABLE II
THE 5-HT CONTENT ($\mu\text{G./G.}$, CALCULATED AS BASE)
OF PLANTAINS DURING RIPENING

Parts of plantain	Days after removal from tree			
	1	3	7	15
Skin	7.5	12.5	22.5	24
Pulp	27.5	63	76	44

mine whether these conditions destroy any 5-HT. Whole ripe fruits so subjected were extracted as described and tested for the amine. Values of 13.7 and 47 $\mu\text{g./g.}$ respectively were obtained for the skin and pulp. No evidence was obtained for the presence of tryptamine, 5-hydroxytryptophan or 5-hydroxyindoleacetic acid in any plantain extract.

Estimation of Catechol Amines

In the rat anaesthetised with urethane, dopamine, 2 to 20 $\mu\text{g.}$, produced a rise in blood pressure. This activity was 20 to 50 times less than that of noradrenaline. From the chromatography results it was estimated that

TABLE III
AMOUNTS OF NORADRENALINE ($\mu\text{G./G.}$, CALCULATED AS BASE)
IN SAMPLES OF PLANTAIN FRUIT

Colour of sample	Pulp	Skin
Yellow-green (unripe)	—	5.1
Yellow-green	—	5.1
Yellow (ripe)	2.5	6.2
Yellow-black (over-ripe) ..	10.1	15.2

the plantain skin contained dopamine, 25 $\mu\text{g./g.}$, which means that no less than 80 per cent of the pressor effect of the acid extract of plantain is due to noradrenaline. An attempt was made to separate dopamine from noradrenaline using chromatographic system (iii). The dopamine area⁵ was eluted and assayed on the blood pressure of the guinea pig anaesthetised with urethane^{6,7}.

The amounts of noradrenaline found in extracts of plantain fruit are shown in Table III. Dibenamine, 1 mg./kg., reduced the response to both standard and extract by a similar amount.

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Estimation of 5-Hydroxytryptamine in other Tropical Fruits

A few experiments were made to supplement the results of Waalkes and others⁸ and of West¹, who have demonstrated large amounts of 5-HT, noradrenaline and dopamine in both the pulp and peel of the banana fruit. No 5-HT was detected in extracts of banana root, stem or leaf, although it was shown to be present in very young fruits up to 3 inches long, in amounts from 1.65 to 7.1 $\mu\text{g./g.}$ of the peel and pulp combined.

Other plants investigated included pineapple (*Ananas comosus*), mango (*Magnifera indica*), passion fruit (*Passiflora foetida*), and papaw (*Carica papaya*), all of which produce edible fruits. Small amounts of 5-HT were shown to be present in papaw (1.1 to 2.1 $\mu\text{g./g.}$) and in passion fruit (1.4 to 3.5 $\mu\text{g./g.}$), but none was detected in the pineapple or mango.

DISCUSSION

These results show that the distribution of noradrenaline and 5-HT are similar in the banana and the plantain fruit. Thus in both, 5-HT is concentrated in the pulp, and its concentration increases as the fruit grows and ripens, the amount decreasing when the fruit is left to overripen. Only traces are present in other parts of the plant.

No evidence was obtained for the presence of 5-hydroxytryptophan, 5-hydroxyindoleacetic acid or tryptamine.

The plantain forms a major part of the diet of the West African. In Yoruba country, plantains are usually fried and eaten as a vegetable, an average of 6 to 15 being eaten each week. A plantain fruit can weigh over 300 g., and according to our results is estimated to contain at least 12 mg. of 5-HT, so that the oral ingestion of 5-HT in plantain may be from 70 to 180 mg. a week. In the villages more plantains are eaten, as there is less variety of food, so that the figures for 5-HT may be raised to over 200 mg. per week.

To study the effects of the regular ingestion of these amounts of 5-HT, students in the College were questioned, and with few exceptions they stated that the usual intestinal effect after a cooked plantain meal was constipation. This seemed interesting in view of the fact that increased intestinal motility and diarrhoea are frequently seen in patients with carcinoid tumours which secrete large amounts of 5-HT. It would not be wise to place too much significance to the questionnaire but at least the present enquiry shows that the ingestion of such large amounts of 5-HT regularly in the form of plantains has little effect on the average Nigerian. While it may be that through prolonged ingestion the Nigerian has become resistant to the toxic effects of 5-HT, many resident Europeans also eat plantain fruits without ill effects.

The ingestion of plantain fruits may lead to the erroneous diagnosis of pheochromocytoma and of carcinoid tumour by increasing the urinary excretion of noradrenaline and 5-HT and their metabolites. While the cooking process would almost certainly destroy the noradrenaline, some of the 5-HT may be absorbed and excreted as 5-hydroxyindoleacetic acid in the urine, and this might lead to erroneous diagnosis of carcinoid tumour. This possibility is being further investigated.

Acknowledgements. The authors wish to express their thanks to Dr. G. B. West of the School of Pharmacy, University of London, for suggestions and generous supplies of 5-HT, 5-hydroxytryptophan, 5-hydroxyindoleacetic acid, 3-hydroxytyramine and 3,4-dihydroxyphenylalanine.

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