

LETTERS TO THE EDITOR

Tryptamines in Edible Fruits

SIR,—Earlier this year, Udenfriend and others¹ reported the rather surprising finding that bananas contain large amounts of two physiologically important agents, 5-hydroxytryptamine (5-HT) and noradrenaline. The presence of these amines in a food as widely used as the banana is of clinical interest since the ingestion of bananas might lead to the erroneous chemical diagnoses of carcinoid tumours and phaeochromocytomas by producing an increased urinary excretion of 5-HT and noradrenaline and their metabolites. The finding is also of biochemical interest as clues might be provided about the biosynthesis and function of these amines in nature.

We have now confirmed that the ripe yellow banana contains 5-HT, noradrenaline and dopamine which are concentrated in the peel rather than in the pulp. The fresh fruits were extracted with acetone (1 g./5 ml.) or with 0·1N HCl (1 g./2 ml.). After reducing the extracts to a small volume, they were subjected to chromatography using 5 different solvent-mixtures. Indoles were detected when Ehrlich's reagent was used as the spray reagent, and noradrenaline and dopamine when potassium iodate was sprayed on to the chromatograms. Duplicate spots were eluted and tested on the isolated rat uterus or on the cat blood pressure. Green under-ripe bananas were then secured and subjected to the same extraction and identification procedures, whilst other green bananas were allowed to ripen or over-ripen before extraction. Whereas large quantities of noradrenaline and dopamine (1–20 $\mu\text{g./g.}$) were found in all extracts, the peel from the green bananas contained only traces of 5-HT (Table I). The appearance of 5-HT in the peel coincided with the development of the yellow colour and therefore may be related to the maturity of the fruit. Although 5-hydroxyindoleamines have been found in plants previously, they have usually been associated with plants regarded as toxic to animals. The significance of 5-HT in the metabolism of the banana is not clear. No evidence of tryptamine, 5-hydroxytryptophan or 5-hydroxyindoleacetic acid was obtained. Further work on the formation and fate of 5-HT in the banana is now in progress.

TABLE I

THE 5-HT ACTIVITY ($\mu\text{G./G.}$) OF PARTS OF THE BANANA AT DIFFERENT STAGES OF MATURITY

Stage	Outer peel	Inner peel	Pulp
Under-ripe	0·1	0·2	25·0
Ripe	52·0	40·0	19·0
Over-ripe	39·0	30·0	22·0

During the systematic examination of other edible fruits, the tomato was found to contain indole derivatives but no noradrenaline or dopamine. Estimated as 5-HT, the activity of green unripe tomatoes was 0·18 $\mu\text{g./g.}$, of red ripe tomatoes 3·75 $\mu\text{g./g.}$, and of over-ripe tomatoes 2·90 $\mu\text{g./g.}$ When the acetone extracts were subjected to paper chromatography, the activity was found to consist of 5 parts of tryptamine to 1 part of 5-HT. The significance of tryptamine in the metabolism of the tomato is also not clear at present. Traces of 5-HT in this fruit may simply represent a means of removing unwanted tryptamine, or the tomato may form its 5-HT through the intermediate substance tryptamine, and not through 5-hydroxytryptophan as in mammals.

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These results are of interest since indole derivatives and noradrenaline-like substances have not been detected in extracts of strawberries, cherries, rhubarb, raspberries, blackcurrants, gooseberries, lemons, oranges, apples, figs, prunes or potatoes.

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July 25, 1958.

REFERENCE

1. Waalkes, Sjoerdsma, Creveling, Weissbach and Udenfriend, *Science*, 1958, **127**, 648.

Penicillin-induced Round Bodies in Gram-negative Bacteria

SIR,—Lederburg^{1,2} has recently shown that if penicillin is allowed to act upon growing cultures of *Escherichia coli* and *Salmonella typhimurium* in hypertonic medium in the presence of Mg⁺⁺, spherical forms or round bodies are generated, due it is postulated, to complete or partial inhibition of cell-wall synthesis during cell division. Similar results are reported for *Pr. vulgaris*³ and *Alcaligenes faecalis*⁴. The term round body rather than protoplast has been retained in describing these forms in accordance with the suggestion of Brenner and others⁵ that the term protoplast should be applied only when there is additional evidence to show that the round bodies contain no cell wall residues.

It is obviously of interest to apply this elegant but simple experiment to other Gram-negative organisms. In our experiments 0.15 ml. of a 17 hour culture of the organism containing about 10⁷ viable cells was inoculated into 10 ml. of a medium containing in each litre: sucrose 114, MgSO₄.7H₂O 2.5, NaCl 5, Lab Lemco 10 and peptone (Oxoid) 10 g., and varying quantities of the potassium salt of benzylpenicillin. Growth was allowed to proceed at 37° for 4–5 hours and the cultures examined by interference microscopy.

The results for 12 organisms are summarised in Table I.

TABLE I

Organism	Concentration of penicillin to induce round bodies (units/ml.)	Diameter of round body (μ)	Size of organism in hypertonic medium without penicillin (μ)
<i>E. coli</i> ¹	4000	3.5–6.0	0.52 × 2.6
<i>E. coli</i> ²	25–100	4.0–5.0	0.52 × 1.7
<i>Cloaca cloacae</i> ³	100–200	6.2–6.8	0.78 × 1.7
<i>Citrobacter freundii</i> ⁴	3000	4.8–5.2	0.52 × 1.7
<i>Klebsiella aerogenes</i> ⁵	1500–2000	4.3–5.2	0.78 × 2.1
<i>Serratia marcescens</i> ⁶	1000–5000	3.5–5.5	0.52 × 0.78
<i>Proteus vulgaris</i> ⁷	1000	3.4–4.3	0.78 × 2.6
<i>Proteus morganii</i> ⁸	5000	5.2–6.0	0.52 × 1.7
<i>Pseudomonas aeruginosa</i> ⁹	250–2000	6.0–6.5	0.52 × 2.1
<i>Pseudomonas hydrophila</i> ¹⁰	4000–5000	5.5–6.5	0.52 × 1.7
<i>Vibrio cyclostitis</i> ¹¹	100	2.6	0.78 × 2.6
<i>Vibrio neocistes</i> ¹²	100	2.6	0.78 × 2.6

¹*E. coli* NCTC 86. ²*E. coli* originally NCTC 5934. ³*Cloaca cloacae* NCTC 8155. ⁴*Citrobacter freundii* NCTC 8165. ⁵*Aerobacter aerogenes* NCTC 8197. ⁶*Serratia marcescens* isolated in the laboratory. ⁷*Proteus vulgaris*—Constantinople OX19 NCTC 7052. ⁸*Proteus morganii*—692 NCTC 417. ⁹*Pseudomonas pyocyanea* NCTC 7244. ¹⁰*Pseudomonas hydrophila*—Kulp NCTC 7810. ¹¹*Vibrio cyclostitis* NCIB 2581. ¹²*Vibrio neocistes* NCIB 2582.