XCVIII. DISTRIBUTION OF VITAMIN C IN DIFFERENT PARTS OF COMMON INDIAN FOODSTUFFS.

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SINCE vitamin C was identified with ascorbic acid several attempts have been made to assay the vitamin in foodstuffs by modifications of Tillman's dichlorophenolindophenol titration method. Bacharach *et al.* [1934] by examining oranges, tangerines and lemons found that vitamin C was present in gradually diminishing amounts from the skin inwards and they suggested that vitamin C was photosynthesised at the skin. A systematic investigation of a large number of foodstuffs was undertaken in this laboratory in order to ascertain the distribution of vitamin C in different parts of the foodstuff. Bessey and King [1933] and Birch *et al.* [1933] give methods of extracting the vitamin from foodstuffs for titration with the indophenol reagent. The author used the following modified method in order to obtain strictly comparable results.

5–10 g. of the substance, or as much as is available, are taken in a mortar and 10 ml. of 20% trichloroacetic acid are added. The mass is then ground into a fine paste with clean sand previously treated with acids, washed and dried. The pasty mass is then stirred up with water and filtered on a Büchner funnel with suction. The residue is transferred to the mortar, 2.5 ml. of trichloroacetic acid are added and the mass is ground up and filtered. The residue is washed 2 or 3 times with water and the combined filtrates made up to 50 ml.; 0.5 ml. of the dichlorophenolindophenol solution (*M*/100 approx.) is taken and 10 ml. of glacial acetic acid are added following upon the observation of Ghosh and Guha [1935] that the addition of the acetic acid inhibits the decolorising action of trichloroacetic acid. The red solution thus obtained is then titrated with the filtrate from a burette until the dye is decolorised. The titration is timed by a stop-watch and is finished in about 1½ min. The dye is next titrated with a solution of ascorbic acid, at about the same rate. The ascorbic acid is finally titrated with *N*/100 iodine solution.

Generally the ascorbic acid contents of the skin and the flesh of fruits and vegetables have been assayed. In some cases the ascorbic acid content of leaves and in two cases that of the seeds have also been determined. It will be seen that in all cases the ascorbic acid is more concentrated in the skin than in the flesh (Table I). The result thus confirms the finding of Bacharach *et al.* It was expected that the leaves of the root vegetables would give higher values than the skin or the flesh and this expectation was realised except in the case of the radish where the difference is within the experimental error.

Quite recently Ranganathan [1935] reported that he had confirmed the results of Bacharach *et al.* in some but not in all cases. McHenry and Graham [1935] also found that in cucumber the ascorbic acid was more concentrated in the skin than in the flesh, but in turnip the reverse was the case, and they advanced an argument to explain this apparent discrepancy. We have, however, failed to

Table I.

Serial No.	Name of food	Scientific name	Ascorbic acid content (mg./g.)			
			Skin	Flesh	Leaves	Seeds
1	Patal	<i>Momordica dioca</i>	0.444	0.25	0.289	0.09
2	Pumpkin	<i>Cucurbita maxima</i>	0.1	0.051	0.1	0.03
3	Ninua	<i>Luffa aegyptica</i>	0.102	0.023	—	—
4	Banana	<i>Musa</i>	0.062	0.052	—	—
5	Plantain	<i>Musa</i>	0.486	0.451	—	—
6	Pear	<i>Pyrus communis</i>	0.072	0.016	—	—
7	Apple	<i>Pyrus malus</i>	0.533	0.202	—	—
8	Radish	<i>Raphanus sativus</i>	0.44	0.16	0.43	—
9	Turnip	<i>Brassica campestris</i>	0.259	0.172	0.393	—
10	Gourd	<i>Lagenaria vulgaris</i>	0.671	0.141	—	—
11	Potato	<i>Solanum tuberosum</i>	0.56	0.363	—	—
12	Tamarind	<i>Tamarindus indica</i>	0.222	0.135	—	—
13	Guava	<i>Psidium guayava</i>	1.854	1.02	—	—
14	Plum	<i>Zizyphus jujuba</i>	3.2	0.337	—	—
15	Do. (another var.)		4.0	0.470	—	—
16	Tomato	<i>Lycopersicum esculentum</i>	0.57	0.39	—	—
17	Carrot	<i>Daucus carota</i>	0.75	0.31	—	—
18	Green chilli	<i>Capsicum</i>	3.9	3.3	—	—
19	Sweet potato	<i>Ipomoea batatas</i>	0.987	0.911	0.993	—
20	Kohl rabi	<i>Brassica oleracea</i>	1.552	0.97	3.264	—
21	Brinjal	<i>Solanum melongena</i>	0.8	0.267	—	—

find this departure from normal in any case. On the other hand we have found that when the fruit or the vegetable is fresh and young the ascorbic acid in the skin is invariably more concentrated than in the flesh; but if the material is dried up, that is, if it is stored for sometime the ascorbic acid of the skin may be less concentrated than that of the flesh (Table II). The obvious explanation

Table II. Ascorbic acid contents of skin and flesh of dried and stored foods (mg. per g.).

	Name	Skin	Flesh
1	<i>Luffa aegyptica</i> (Ninua)	0.022	0.029
2	Plantain	0.092	0.099
3	Sweet potato	0.703	0.90

is that the ascorbic acid of the skin, being exposed to atmospheric action, begins to deteriorate while that in the flesh, being protected by the outer coating, remains unharmed and intact for considerably longer periods. The failure of Ranganathan to detect ascorbic acid in the skin of the plantain or banana may be due to his method of extraction with 8% acetic acid. Ghosh and Guha [1935] have adduced evidence that trichloroacetic acid fails to extract all the ascorbic acid from germinating mung. McHenry also points out that one extraction with trichloroacetic acid fails to extract all the ascorbic acid. We have also found that our method of extracting twice with trichloroacetic acid (20%) failed to extract all the ascorbic acid from some materials.

Examination of animal foods has revealed that the liver is the richest in ascorbic acid whilst muscle is the poorest (Table III).

Table III. Ascorbic acid contents of animal foods (mg. per g.).

	Name	Liver	Kidney	Heart	Muscle	Bone-marrow	Milk
1	Goat	0.263	0.176	0.077	0.066	0.088	0.085
2	Hilsa (<i>Clupea ilisha</i>)	0.48	—	—	0.276	—	—

SUMMARY.

It has been found that vitamin C is more concentrated in the skin of fruits and vegetables than in the edible portion. In the case of root vegetables vitamin C is in the greatest concentration in the leaves. Animal foods gave the following result in regard to their vitamin C contents:

liver > kidney > bone-marrow > milk > heart > muscle.

REFERENCES.

- Bacharach, Cook and Smith (1934). *Biochem. J.* **28**, 1038.
Bessey and King (1933). *J. Biol. Chem.* **103**, 687.
Birch, Harris and Ray (1933). *Biochem. J.* **27**, 590.
Ghosh and Guha (1935). *J. Ind. Chem. Soc.* **12**, 30.
McHenry and Graham (1935). *Biochem. J.* **29**, 2013.
Ranganathan (1935). *Ind. J. Med. Res.* **23**, 239.