

THE ANALYSIS OF CEYLON FOODSTUFFS

IV.—THE VITAMIN C CONTENTS OF SOME CEYLON FRUITS AND VEGETABLES

A. W. R. JOACHIM, Ph.D., Dip. Agric. (Cantab.),

CHEMIST

AND

C. CHARAVANAPAVAN, B.Sc. (Hons.)

THE isolation of vitamin C by Waugh and King (1) following on the work of Szent-Gyorgyi (2), who identified the vitamin with a reducing substance named subsequently hexuronic or ascorbic acid has rendered possible its estimation in natural sources by a purely chemical method. Tillmans and associates (3) used the oxidation-reduction indicator 2:6 dichlorophenol indophenol for the direct estimation of the vitamin, and his method, modified by others, is now widely adopted. The method has been responsible for much subsequent work on the subject, as a result of which our knowledge of the nature and distribution of vitamin C in plant and animal substances has been considerably enhanced. It would suffice here to state that Tillmans' method as modified by Birch (4) and Bessey and King (5) may underestimate the vitamin C content of the material examined. It is now known that vitamin C may exist in an "active" as well as a "reversibly oxidised form", both of which function biologically. It is the former only which may be estimated by the titration method.

Within recent years the vitamin C contents of Indian foods has been determined by Ahmad (6), Ranganathan (7), Chakraborty (8), Guha and Ghosh (9), and others. Their data are of interest, as many of the fruits and vegetables studied by them are found locally. The investigation, the results of which are now presented, covers a wide range of local fruits and a few

of the local leafy vegetables, the total number of materials examined being over 50. As fresh material as possible was used in view of the observation that the vitamin C contents of fruits and vegetables decrease on keeping.

EXPERIMENTAL

The method of estimation used was as follows: from 10 to 25 grms of the fresh material were ground up with fine, clean sand and 10–15 cc of trichloroacetic acid. With certain fruits acetic acid was used as the extractive agent, and with other fruits again, *e.g.*, citrus fruits, the fresh juice alone was used for the determination. The extract was strained through muslin, and if coloured, cleared with lead acetate followed by the removal of lead with sodium sulphate. The final extract was made up to 40 cc–60 cc with the acid. Following on the work of Guha and Ghosh (9), 1 cc of glacial acetic acid was finally added to the extract when trichloroacetic acid was used, in order to prevent the rapid fading of the colour during titration. The extract was then titrated against a known volume of the indicator, 2:6 dichlorophenol indophenol. The indicator solution was prepared by dissolving .02 gm. of the dye in 100 cc of warm water. This was standardized against a freshly-prepared solution of ascorbic acid in glass-distilled water. The ascorbic acid was standardized against a .01 N iodine solution, prepared by dissolving the required quantity of iodine in a litre of water containing 15 gm. of potassium iodide. The dye titration itself was quite simple, the extract being added from the burette to a measured volume of the dye solution (1 to 5 cc) till the colour of the latter was destroyed. With fairly coloured extracts, the titration was carried out to the point when rapid fading of the pink colour ceased. Fruits which gave very highly-coloured extracts, *e.g.*, the tree tomato, could not be examined for vitamin C content by this method. The extract was then titrated against a .01 N solution of iodine with starch as the indicator. 1 cc of .01 N iodine is equivalent to .88 mgm of ascorbic acid. This method is not accurate for fruit juices containing substances like sugars which react with iodine.

The results of the determinations are set out in tables I and II, the former showing the vitamin C contents of fruits and the latter of the vegetables. Sugarcane is included in the first and betel leaf, tamarind, chillies, and onions in the second table. For purposes of comparison Ahmad's results where available are indicated, as these are similar to those obtained locally. In a few cases the figures of Chakraborty (8) or Ghosh and Guha (9) are quoted. Ranganathan's (7) figures are appreciably higher than those of other Indian workers.

TABLE I

Fruits

Name	Vitamin C (Ascorbic Acid) Mgs per 100 gms or 100 cc.	Indian Figures	Remarks
Guava	.. 127	.. 90-104	.. Large country variety ; numerous seeds
Papaw	.. 61	.. 48	.. —
Orange	.. 57	.. 31.2	.. Very sweet Vavuniya fruit
..	.. 49.3	.. —	.. Navel orange from Peradeniya
Grapefruit	.. 48	.. 38.5	.. Marsh's seedless variety from Peradeniya
Mandarin	.. 45	.. —	.. Well matured, sweet, Peradeniya
Pummelo	.. 41	.. —	.. Well matured from Colombo
Lemon	.. 37	.. 38.5	.. From Peradeniya
Lime	.. 31	.. 16.8	.. British Guiana variety from Peradeniya
Seedless lime	.. 28	.. —	.. —
Mango	.. 80	.. —	.. <i>Ambalavi</i> from Jaffna
..	.. 58	.. —	.. Parrot (<i>Gira</i>) variety from Kandy
..	.. 55	.. —	.. From Jaffna
..	.. 35	.. —	.. Peradeniya <i>Beti</i> variety
..	.. 15	.. 13-15	.. <i>Chembatan</i> from Jaffna
..	.. 15	.. —	.. —
Hog plum	.. 42	.. —	.. <i>Spondias mangifera</i>
Rambutan	.. 35	.. —	.. <i>Nephelium lappaceum</i>
Tomato	.. 27	.. 26	.. Large variety
..	.. 15	.. —	.. Local small variety
Tree tomato	.. 11	.. —	.. <i>Cyphomandra betacea</i>
Peach (local)	.. 26	.. —	.. <i>Prunus persica</i>
Soursop	.. 15	.. —	.. <i>Annona muricata</i>
Custard apple	.. 16	.. 15	.. <i>Annona squamosa</i>
Jambu	.. 11	.. —	.. Pink variety, <i>Eugenia</i> spp.; by iodine method
Pineapple	.. 14.5	.. —	.. Local Mauritius variety
..	.. 14	.. 7-28.5	.. Local Kew variety
Bilin	.. 10	.. —	.. <i>Averrhoa bilimbi</i>
Jak	.. 7	.. —	.. <i>Artocarpus integra</i> , ripe
Young coconut	.. 3.1	.. —	.. Pulp
..	.. 1.5	.. —	.. Water
King coconut	.. 4.3	.. —	.. Pulp
.. coconut	.. 1.3	.. —	.. Water
Palmyra	.. 1.0	.. —	.. Young fruit ; <i>Borassus flabellifer</i>
Toddy, fresh	.. 7.2	.. —	.. <i>Caryota urens</i> , kitul
Toddy, fermented	.. 1.3	.. —	.. —
Bael	.. 3.0	.. 7.6	.. <i>Aegle marmelos</i>
Woodapple	.. 2.0	.. —	.. <i>Feronia elephantum</i>
Plantain	.. 1.3-2.0	.. 0.1-3.2	.. Ripe ; <i>embul hondarawela</i> , <i>puvalu</i> and <i>koli-</i> for bananas <i>kuttu</i> varieties
Mangosteen	.. 1.0	.. —	.. <i>Garcinia mangostana</i>
Sugarcane	.. 0.36	.. .2	.. —
Pomegranate	.. 0.20	.. 1.56	.. Fruit not fresh
Avocado pear	.. Trace	.. —	.. —

DISCUSSION

An examination of table I will indicate that of local fruits the guava, papaw, citrus spp., and certain varieties of mangoes are rich in vitamin C. Of the citrus species local oranges, grapefruit, mandarins, and pomelos are of about equal antiscorbutic value. Limes, though of fair vitamin C content, have lowest values. Locally-grown lemons apparently have lower vitamin C values than imported fruit. Mangoes vary largely in their vitamin content with variety and place of growth. This is the experience of the Indian workers as well. The condition of the fruit is also an important factor. Overripe fruit are poor in

vitamin C. It was observed in the course of this work, that mature fruits rapidly lose vitamin C on keeping. This is in conformity with what has been found by other workers with fruit as well as vegetables (6, 9). Acidity and absence of air favour the retention of vitamin C, while high temperatures, oxidation and alkalinity favour the destruction of the vitamin. This is one reason why the addition of bicarbonate of soda in cooking fruit or vegetables is disadvantageous. Prolonged cooking would also result in a loss of the vitamin. Fruits like the tomato, hog plum (*Spondias mangifera*), rambutan (*Nephelium lappaceum*), custard apple, and soursop (*Annona muricata*) have fair vitamin C contents. Pineapples grown locally for some reason or other give lower values than might be expected. This is probably because the fruit though not over-ripe, were not as fresh as was desirable. The figures correspond closely with those of Ghosh and Guha (9). Plantains, mangosteens, woodapple (*Feronia elephantum*), bael fruit (*Aegle marmelos*) and sugar cane juice are poor sources of the vitamin. Local avocado pears (*Persea gratissima*) have only a trace of vitamin C. Young coconut kernel and coconut water are poor sources of vitamin C, the water however having from two to three times the vitamin value of the pulp. Fresh toddy has more vitamin C than fermented toddy, but the values are not high.

That wide variations can exist in the vitamin C contents of individual samples of fruits and vegetables will be apparent from one of the latest bulletins of the United States Department of Agriculture, entitled "Vitamin Contents of Foods" (10). The knowledge that certain varieties of fruits or vegetables can be rich sources of vitamin C will certainly be helpful in framing diets, but it must be emphasized that the actual nutritive benefit derived from the fruit or vegetable will depend largely on the variety and condition of the particular sample.

TABLE II
Vegetables

Name	Vitamin C (Ascorbic Acid)		Indian Figures	Remarks
	Mgs per 100 gms. or 100 cc.			
Agathi	.. 181	..	—	.. <i>Sesbania grandiflora</i> leaves
Drumstick	.. 80	..	—	.. <i>Moringa oleifera</i> pods
"	.. 3	..	—	.. Leaves
Spinach	.. 66	..	31	.. —
Chillies	.. 50.5	..	—	.. <i>Capsicum annuum</i> , large
"	.. 13	..	—	.. " " small
Mukunuvanna	.. 33.0	..	—	.. <i>Alternanthera triandra</i>
Onions	.. 11.0	..	10.5	.. <i>Allium cepa</i> small, by iodine method
Tamarind	.. 1.4	..	1.4	.. <i>Tamarindus indica</i> (dried)
Gotu-kola	.. 1.2	..	—	.. <i>Centella asiatica</i>
Ash plantain	.. 0.5	..	—	.. <i>Musa paradisiaca</i>
Betel leaf	.. 3.4	..	6.1	.. <i>Piper betle</i>

From table II above it will be seen that *agathi* (*Sesbania grandiflora*) leaves, drumstick (*Moringa oleifera*), spinach, chillies and *muknuvenna* (*Alternanthera triandra*) are good sources of vitamin C. Ranganathan (7) reports that vegetables like *kankun* (*Ipomoea aquatica*) and bitter gourd (*Momordica charantia*) are also rich in the vitamin, but until a new stock of dye is available their investigation locally has to be deferred.

SUMMARY

The determination of vitamin C values by the dichlorophenol indophenol method have indicated that guavas, citrus spp., papaws, certain varieties of mangoes, rambutans, hog plums, and tomatoes are fruits of good vitamin C content, while avocado pears, plantains, coconut, jak, bael, mangosteens, woodapples, and sugar cane are poor sources of the vitamin. Soursop, custard apple, pineapples, tree tomatoes and bilimbi are of intermediate value. Of the vegetables examined, *agathi*, drumstick, spinach, chillies, and *mukunnuvenna* are rich sources of the vitamin, while ash plantain and *gotukola* are very poor in it.

REFERENCES

1. Waugh, W. A., and King, C. G.—*Jour. Biol. Chem.*, 97, 1932.
2. Szent-Gyorgyi, A.—*Biochem. Jour.*, 22, 1928.
3. Tillmans, J., Hirsch, P., and Hirsch, W. Z.—*Untersuch. Lebensmittel*, 63, 1932.
4. Birch, T. W., and Dann, W. J.—*Nature*, 131, 1933.
5. Bessey and King.—*Jour. Biol. Chem.*, 103, 1933.
6. Ahmad, B.—*Ind. Jour. Med. Res.*, 22, 1935.
7. Ranganathan, S.—*Ind. Jour. Med. Res.*, 23, 1935.
8. Chakraborty, R. K.—*Ind. Jour. Med. Res.*, 23, 1935.
9. Ghosh, A. R., and Guha, B. C.—*Jour. Ind. Chem. Soc.* 12, 1935, and *Nature*, 1935.
10. Daniel, E. P., and Munsell, H. E.—*U. S. Dept. Agr. Mis. Publ.* 275.