BIOCHEMICAL AND NUTRITIONAL STUDIES ON EAST PAKISTAN VEGETABLES

Part I.—Total Ascorbic Acid in East Pakistan Vegetables, its Co-existence with Plant Pigments and the Effect of Traditional Cooking Habit on its Retention

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The total ascorbic acid content, including the dehydroascorbic acid, of some leafy tuberous and fruity vegetables grown and consumed in East Pakistan have been investigated.

As in a previous report, the relationship in the co-existence of ascorbic acid with anthocyanin pigments was also observed in many vegetables like red-skinned sweet potato and violet-skinned brinjal (*Solanum melongenala*), in the red pepper, and in ripe fruits like utche *Memordica balsamina* and Kakrol (*Memordica cochinchinesses*) with pigmented skin. In the study of the influence of utensils on the loss due to cooking it was observed that this loss depends partly on the nature of the utensil and partly on the total time required, which on the other hand, is related with the nature of the vegetables and size of their slices.

Introduction

East Pakistan produces annually about 1.1 million tons of edible vegetables. These vegetables partly belong to the tubers like potato, sweet potato etc. and partly to the fruits like brinjal (*Solanum melongenala*), cucumber, gourd etc. The stems and leaves of some plants like *Amaranthus*, *Colocasia*, *Ipoemea aquatica* and of some creepers like *Basella*, *Cucurbita masuma*, *Lagenaria vulgaris* etc. are also listed as vegetable foodstuff in this region. From the literature compiled by F.A.O. it appears that the vegetables supply a fair amount of minerals and vitamins to the dietaries. But it is not definitely known how much of the total minerals and vitamins of the typical rice dietaries of this region is actually available from the vegetable constituents of these diets. The recent researches [2,3] regarding the importance of the plant leaves as a source of protein of high biological value following the classical work by Chibnal[4] in this line has opened a new field for study of the quantity and nature of protein constituents of the plant leaves and other vegetables as consumed by the people of this region. Moreover, since time immemorial traditional prosesses of cooking of the vegetable curries in open pan made of different materials is being practised but there is no report as to the total loss of the vitamins, minerals and other constituents and change in the nutritive value of the protein due to such cooking habit. Systematic investigations have, therefore, been undertaken to study all the above aspects of the different vegetables grown in this region and the present report submits results about the total ascorbic acid, including its oxidised dehydro form, which was also found to be active in the human system as reported by Hirst and Lilva,[5] and on the loss due to cooking habit in the earthen, iron and aluminium utensils. In course of this investigation, the study was also extended to evaluate the relationship of the co-existence between plant pigments and ascorbic acid about which a detailed report on pigmented radish has already been communicated earlier by Qudrat-i-Khuda, De and Shariff.[1]

Previous report on the chemical behaviour of ascorbic acid has shown that this vitamin is very susceptible to oxidative destruction by contamination with iron, copper and aluminium[6,11] though to varying degrees. The loss on cooking so far reported in the literature[12,22], relates to the investigations mainly devoted to the study of the household cooking processes prasticed in the Western countries but there is little information about the total loss of ascorbic acid of different vegetables which may be effected when these are cooked in the iron, aluminium and earthen utensils, up to the stage of softness and palatability. In view of the paucity of information in this line it is expected that the present report will throw new light on this aspect of nutritional behaviour of the vitamin C of the vegetables of this region as affected by the traditional cooking habits.

Experimental

It has been reported by a group of workers[23-25] that plant tissues also contain, in addition to free ascorbic acid (AA), some quantities of its oxidised form, dehydroascorbic acid (DAA), and the latter had been expressed as total AA after converting this to its reduced form, i.e., to ascorbic acid (AA). In the present report also both the forms have been expressed as total AA after converting the DAA to AA by passing H_2S and removing the excess of H_2S by a stream of nitrogen according to the technique of Melnick, Hochberg and Oser[26] and finally measuring the total AA

TABLE I.— THE TOTAL ASCORBIC ACID, INCLUDING DEHYDROASCORBIC ACID AND LOSS OF TOTAL ASCORBIC ACID DUE TO COOKING IN GLASSWARE, ALUMINIUM, IRON AND EARTHEN UTENSILS.

Botanical name of the vegetables	Local name	Total AA including the DHA in mg.p. cs.	Average weight of the piece used for cooking g.	Glassware cooking			Iron utensil cooking			Aluminium utensil cooking			Earthen utensil cooking		
				Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GROUP A															
Leaves and Stems															
1. Ipoemea aquatica (Forsk)	Kalmi Sak	10.4	0.1	68	22	3.3	100	19	5.3	80	17	4.7	76	23	3.3
2' Basella alba	Puin Sak (white variety)	14.2	0.2	63	21	3.0	100	19	5.3	74	18	4.1	62	22	2.8
3. Colocasia macrorhiza, (Schoff)	Kachu Sak	7.7	0.1	60	21	2.9	100	19	5.3	82	17	4.8	72	25	2.9
4. Amaranthus	Data	25.0	—	—	—	—	—	—	—	—	—	—	—	—	—
5. Nymphaea lotus var. Sampala	Sapla	9.1	1.0	58	20	2.9	98	20	4.9	78	19	4.1	62	25	2.5
GROUP B															
Fruits															
6. Cucurbita maxima (Dutch)	Misti Kumra	17.2	6.7	42	13	3.2	66	17	3.9	62	13	4.7	52	15	3.2
7. Benincasa Corifera (Sair)	Chal Kumra	27.6	10.0	48	24	2.0	68	25	2.7	64	23	2.8	58	28	2.0
8. Trichosanthes anguina, L.	Chichinga	21.2	8.8	60	25	2.4	76	27	2.8	72	24	3.0	70	30	2.3
9. Lagenaria vulgaris	Lau or Kadu	8.6	9.6	56	22	2.5	70	24	3.0	68	20	3.4	60	28	2.1
10. Cucumis sativus, L.	Cucumber	15.8	11.2	78	24	3.2	89	31	2.8	90	27	3.3	91	31	2.9
11. Trichosanthes dioica Roxb	Potol	27.0	3.6	46	26	1.8	76	30	2.3	65	25	2.6	66	31	2.1
12. Luffa acutangula	Jhinga	15.3	5.6	72	25	2.9	88	24	3.7	90	22	4.1	87	31	2.9
13. Luffa aegyptiaca Mill	Dhundul	23.7	3.4	48	19	2.5	62	21	3.0	60	18	3.3	58	24	2.4
14. Hibiscuss esculentus, L.	Dheras	16.4	0.5	72	23	3.1	100	25	4.0	88	24	3.7	83	30	2.8
15. Memurdica cochin chinesis, Spring	Kakrol (yellow-skin-ripe)	107.8	2.5	44	24	1.8	53	22	2.5	57	21	2.7	52	27	1.9
16. Memordica charantia	Karella	69.0	3	48	24	2.0	60	23	2.6	66	23	2.9	52	25	2.1
17. Carica papaya	Papaya	32.6	6	58	31	1.9	87	30	2.9	85	27	3.1	76	35	2.1
18. Phaseolus vulgaris	Seam (green skin)	10.8	2.5	48	22	2.2	62	22	2.8	54	20	2.7	50	25	2.0
19. Vigna catiang	Barbati	28.8	4.5	46	25	1.8	71	25	2.8	62	22	2.9	60	31	1.9
20. Musa paradisica, L.	Kancha Kala	14.4	6	68	22	2.8	87	20	4.3	76	18	4.0	80	27	2.9
21. Brassica (Pleracea) botrytis	Cauliflower	44.0	7	63	22	2.9	77	20	3.8	79	23	3.4	79	26	3.1
22. Brassica oleracea, L.	Cabbage	58.2	2.5	59	20	2.9	81	18	4.4	77	22	3.4	77	26	3.2

TABLE I.—(*Continued*).

Botanical name of the vegetables	Local name	Total AA including the DHA in mg.p. cs.	Average weight of the piece used for cooking. g.	Glassware cooking			Iron utensil cooking			Aluminium utensil cooking			Earthen utensil cooking		
				Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute	Per cent gross loss	Time reqd. in minutes	Per cent rate of loss per minute
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
GROUP C															
Bulbs and Tubers															
23. Solanum tuberosum, L.	Potato	7.8	5.5	42	21	2	62	20	3.1	55	18	3.0	50	26	1.8
24. Ipoemea batata	Sweet potato	26.5	6.5	48	26	1.8	76	24	3.1	78	22	3.5	60	30	2.0
25. Brassica campes tris L.	Shalgam	31.4	6.0	60	31	1.9	76	31	2.4	90	28	3.2	70	38	1.8
26. Raphanus sativus	Radish	36.6	5.0	57	33	1.7	72	30	2.4	69	28	2.5	62	35	1.8
27. Daucus carola	Gazar	6.1	2.0	41	25	1.6	63	28	2.2	66	30	2.2	54	34	1.6
28. Bulbs of colocasia antiquorum	Kachu mukhi	6.4	3.0	46	15	3.0	58	15	3.2	62	16	3.9	50	18	2.8
29. Runner of colocasia antiquorum	Kachu lata	11.2	3.0	55	32	1.7	78	31	2.5	70	29	2.8	64	37	1.7
	Average			55.3	23.5	2.4	76.6	23.6	3.2	72.0	21.6	3.3	65.0	27.9	2.4

by microtitration against indophenol dye by adopting the method of Harris and Oliver,[27] as follwoed in the previous investigations by De and Barai[28] and Qudrat-i-Khuda, De and Shariff.[1]

For the study of the loss of ascorbic acid due to cooking in different utensils, 25 g. of vegetables sliced into small pieces by glass cutter were boiled in iron, aluminium and earthen utensils with 100 c.c. distilled water. For assessing the effect of the ingredients of the utensils on the loss due to cooking, similar batch of 25 g. was boiled in neutral glass beaker (Jena glass). The average weight vegetables used for cooking are indicated in Table 1. Cooking in all the utensils was continued upto the period when the vegetables became soft and ready for eating. The time required for cooking of each vegetable in different utensils was noted so as to explore the effect of time on the total loss of ascorbic acid due to cooking.

After cooking, the entire contents including the extract were analysed for total ascorbic acid and from these residual values the total loss and the rate of loss per minute due to cooking of individual vegetable in the above four utensils, was then calculated.

The results of total ascorbic acid values including those of dehydroascrobic acid in fresh vegetables, the total loss, time required for cooking and the rate of loss are presented in Table 1. The results as to the effect of pigment of the skin on the ascorbic acid content of some vegetables are shown in Table 2.

Results and Discussion

From the results it would appear that there is a great variation in the total ascorbic acid (AA) contents of the different vegetables produced and consumed in this region. Among the leaves, that from the plant *Amaranthus* contains greater quantity as compared to those from kalmi (*Ipoemea aquatica*) and kachu (*Colocasia macrorrhiza*) plants. In the list of the fruity vegetables, maximum AA was noted in ripe 'kakrol' (*Memordica cochinchinese*) which is generally consumed after formation of pigments on the skin. It appears that the higher content in the leaves of *Amaranthus* and in the kakrol is probably due to the presence of pigment. This pigment-ascorbic acid relationship is further made explicit from the results of Table 2 which show high values in ripe pepper and ucche (*Memordica balsamina*) as compared to their green samples collected from the same batch. Even

TABLE 2.—THE INFLUENCE OF PIGMENT OF THE SKIN ON THE ASCORBIC ACID CONTENTS.

Botanical name	Local name	Percent of total AA including DHA in mgm.
Capsicum annuum	Pepper, small variety, green stage	40.2
	Ripe stage, red skin	78.4
Memoradica balsamina	Ucche, green stage	27.9
	Ripe stage, red pigmented skin	51.2
Memorandica cochinchinese spring	Kakrol, green unripe	77.6
	Kakrol, ripe, yellowish red pigment skin	107.8
Phaseolus vulgaris	Seam (Bean), non-pigmented variety	10.8
	Seam (Bean), violet skin variety	18.6
Solanum melongenala	Brinjal, round, white skin variety	7.8
	Brinjal, round, violet skin variety	17.2
Solanum melongenala	Brinjal, long, green skin variety	6.2
	Brinjal, long variety, deep bluish violet skin	9.4
Solanum tubeosum	Potato, oblong shape, light yellow skin variety	7.8
	Potato, round purple skin variety	19.2
Ipoemea batata	Sweet potato, light yellow skin variety	26.5
	Sweet potato, violet skin variety	35.8

the varietal difference with pigmented and non-pigmented skin also shows similar relationship as evident from the higher ascorbic acid values of violet skin sweet potato (*Ipoemea batata*) and brinjal (*Solanum melongenala*) as compared to the non-pigmented varieties. This substantiates our previous findings[1] on the anthocyanin-ascorbic acid relationship in radish where it has been seen that more ascorbic acid was concentrated in the pigmented portion than in the non-pigmented ones. It seems very much plausible, as hypothesised in the previous report, that anthocyanin may stabilise or form complex compound with ascorbic acid.

Effects of Utensil on the Time of Cooking.—From the results it would appear that for complete cooking of the different vegetables up to the stage of their palatibility aluminium utensil required the minimum time of 21.6 minutes on an average and the earthen utensil the maximum of 27.9 minutes. Iron utensil and laboratory glassware required almost equal time of 23.6 to 23.5 minutes respectively in between the above two extremes.

Gross Loss and Rate of Loss of Ascorbic Acid.—The average gross loss, however, was not in harmony with the time of cooking mentioned above. In this case maximum loss of 76.3% was noted in the case of iron utensil and minimum of 55.3% in the case of glassware. The losses due to aluminium and earthen utensils were found to be 72.0% and 65.0%, respectively. These variations are the effect of utensils as discussed below. However, it thus appears that the time of cooking and the nature of the utensil play the part independently in effecting the loss of ascorbic acid due to cooking. Their joint effect is clearly evidenced when the total loss is expressed as the rate of loss per minute of cooking. Calculating in this way it was strikingly observed that both earthen utensil and glassware effected equal rate of loss of 2.4% whereas the other two caused a greater rate of loss almost to the same range of 3.2 to 3.3%.

From the values of the gross loss it may be well conceived that comparatively lower loss in glassware cooking is simply due to the combined effect of temperature and time of exposure to the air, whereas in the case of other utensils, additional factor, i.e. the constituents of the utensils, plays an important role which ultimately causes greater loss due to cooking in these utensils. In order to judge the influence of the constituent of utensil in particular, on the actual loss, the following formula has been applied correcting for the loss due to time factor and due to glassware cooking alone:—

If A represents the per cent gross loss due to cooking in any utensil, A^1 represents the per cent gross loss due to cooking in glassware, B represents the total time required for cooking in any utensil, B^1 represents the total time required for glassware cooking and C represents the rate of loss per minute due to glassware cooking, then the actual per cent loss due to influence of material of the utensil alone $= (A^1\text{-}A) - (B^1\text{-}B) \times C$.

TABLE 3.—THE ACTUAL PERCENT LOSS ON COOKING DUE TO INFLUENCE OF UTENSIL.

Nature of utensil	Glass	Iron	Aluminium	Earthen
Gross loss %	55.3	76.3	72.0	65.0
Total time required in minutes	23.5	23.6	21.6	27.9
Rate of loss per minute %	2.4	3.2	3.3	2.4
Loss due to untensil %	—	20.76	21.26	0.8

The value of actual per cent loss due to the effect of utensil calculated by the application of the above formula is shown in Table 3.

From the results shown in Table 3, it is observed that the actual loss effected due to the influence of the material of the utensil, after allowing equal time of heating and equal rate of loss as per glassware cooking, is only 20.76% for iron and 21.26% for aluminium. Very strikingly earthen utensil showed almost no loss indicating that the ingredients of the earthenware do not cause any actual loss of ascorbic acid. The apparent gross loss as observed is mainly due to the effect of longer time required for cooking in such utensil. In both iron and aluminium utensils the apparent gross loss is the combined effect of the total time of cooking as well as of the constituents of the utensils.

Effect of Slicing on the Total Loss.—Now, the total time required for complete cooking of the vegetables differ for individual species of vegetables. From Table 1 it is apparent that the tuber products like potato etc. of group C required more time for cooking, in all utensils used, than the fruity vegetables like potol (*Trichosanthes dioica*), papaya etc. of group B. The leafy vegetables of group A, however, required minimum time for cooking. This variation in the time required for cooking is also partly dependent on the way in which the vegetables are sliced. The fruity and rooty vegetables are sliced longitudinally and also laterally into moderately small pieces each weighing on an average 0.5 to 10 g. Leaves, on the contrary, are sliced into thin pieces, 8 to 20 of which weigh only 1 g. Thus in the leaves more surface area per g. is exposed to the air as compared to that in other vegetables. Due to thin slicing, less time is, however, required for their cooking, but due to exposure of greater surface area, the loss in these leafy vegetables is comparatively high, specially when cooked in iron utensils. A similar phenomenon is also noted in the case of lady's-finger where the loss is very high in spite of comparatively low time of cooking. This is because of the hollowness of the fruit for which the weight of the slice is very small and more surface is thus exposed to the air and to water like the leafy vegetables.

In addition to the above, there are some other pre-cooking factors like slicing by iron knife, exposure of the slices to the air before cooking, washing and bruising of the slices in water and throwing of the washed water away. These factors also cause some amount of loss which ultimately shows higher overall effect after the cooking is complete. Loss due to each of these factors has to be carefully determined before any conclusion is drawn with regard to the loss of ascorbic acid and other vitamins due to the cooking methods in this region.

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