

## CHANGES IN THE CAROTENE AND ASCORBIC ACID CONTENT OF MANGOES DURING RIPENING.

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In a previous work \* (Banerjee and Ramasarma, *Agric and livestock in India*, 1938, 8, 253) it was found that the vitamin content of mangoes varied very much from one variety to another and even in the same variety of mango, considerable variation was observed between different samples. Mango is one of the best of tropical fruits and is a very rich source for vitamins A (carotene) and C. So it was thought desirable to study the factors influencing the vitamin content of the fruit. In the present investigation the changes in the carotene and ascorbic acid content of mature mangoes during the usual ripening process have been studied.

Mango fruit is not allowed to ripen on the tree as it drops down before it is ripe and is liable to be spoilt in other ways. After picking, it is stored at room temperature which varies from 30° to 40°C in the plains. During storage the cell activity continues and the ripening changes take place. The stages of ripening can be better illustrated in terms of acidity or carbohydrate changes than colour or texture variations. They are expressed in the following table.

TABLE I

Stage of ripening	Acidity in c.c. of N/10 alkali to neutralise 10 gms of pulp	Reducing sugars as glucose %	Total sugars %	Total carbohydrates %
Green	15.0	1.1	2.8	15.9
Half ripe	11.5	2.6	7.8	16.2
Ripe	1.5	3.1	14.2	15.6
Fully ripe	2.9	2.7	14.9	15.2

\* *N B*—In Table II of this paper "Vitamin C in mg. per kg." should be read as "Vitamin C in mg. per gm."

Ranganathan (*Ind Jour Med Res*, 1936, **23**, 755) has estimated vitamin C in mangoes during ripening. He used for his experiments mangoes which had been kept in the cold store at 0°C for about a fortnight. This must have killed all cell activity and thus affected the normal ripening process as found out by Bancroft and others (*Agric and Livestock in India*, 1931, **4**, 36), Chenna and coworkers (*Miscell Bull* No 21, of I C A R, India, 1939) and Wardlaw and Leonard (*Low Temp Res Sta, Imp Coll Trop Agric, Trinidad*, Mem No 3, 1936, *Tropical Agriculture*, 1937, **17**, 230).

The concentration of ascorbic acid in the skin of most fruits is higher than that of the inner pulp and this variation in the vitamin C content of the different parts of fruit and vegetables may be related to their metabolic activity (Bracewell *et al*, *Biochem J*, 1931, **25**, 138; Bacharach *et al*, *Ibid*, 1931, **28**, 1038; Rudra, *Ibid*, 1936, **30**, 701). Therefore an attempt is made to see if there is any transference of ascorbic acid from the skin to the flesh or vice versa during the ripening of the mangoes after plucking.

De (*Ind Jour Med Res*, 1937, **24**, 737) observed a progressive increase in the carotene content of mangoes as they ripen and the change from a pale yellow colour to a bright orange has been found to be a fair indication of the increase. In the present investigation determinations were made for the carotene content also of the mangoes at various stages of ripening.

## EXPERIMENTAL

*Season 1938* — Three lots of mangoes were plucked at the mature stage when they are usually removed from the tree by the growers for commercial purposes. The lots consisted of about 50 mangoes each, plucked carefully from three different trees in an orchard near Bangalore, the first two were of the Badami variety which is very rich in both carotene and ascorbic acid and the third of the Malgoa variety. The mangoes were allowed to ripen under straw

in a closed wooden box provided with holes for ventilation. Samples were taken at random and determinations were made for the carotene content of the pulp and ascorbic acid content of both the pulp and the skin. When they were fully ripe they were placed in the cold room at 0°C and the vitamin changes during storage were studied.

It was found by trial that representative samples could be had by taking longitudinal peels of the flesh and skin of the mango for the estimations. Ascorbic acid was estimated by the titration method of Harris and Ray (*Biochem J*, 1933, **27**, 303) as modified by Musulin and King (*J Biol Chem*, 1936, **116**, 109). The experimental procedure was the same as that described by Oliver (*Analyst*, 1938, **63**, 2). The final extract contained 5 per cent trichloroacetic acid and 2 per cent metaphosphoric acid. The strength of the 2,6-dichlorophenolindophenol solution was checked from time to time using the new iodimetric method (McNaker and Guernant, *Ind Eng Chem Anal Edn*, 1938, **10**, 25, Buck and Ritchie, *Ibid*, 1938, **10**, 26).

Carotene was estimated colorimetrically. The weighed mango pulp was ground in a mortar and pestle with a small quantity of acetone, the acetone was decanted off and filtered over cotton wool. The residue was ground and extracted with successive portions of acetone till no more pigment was extracted. Petroleum ether (B.P. 60-90°C) was added to the collected acetone extracts and enough water was added to separate the petrol and acetone layers. The pigments were taken up by the petrol which was washed free from acetone with water and saponified. Separation of carotene and xanthophyll was effected by shaking the petrol solution with 85-90 per cent aqueous methyl alcohol, carotene remained in the petrol layer while the xanthophyll passed off into the methyl alcohol. The solutions were made up to required volumes, matched in the colorimeter against 0.1 per cent potassium dichromate solution and the carotene content calculated with the help of the curves given by Ferguson (*Analyst*, 1935, **60**, 680). The results are given below in Tables II, III and IV.

TABLE II

*Balaram mangoes plucked on 20th May 1938*

No of days after plucking	Description	Vitamin C in mgms per gram		Carotene mgms per kg
		Pulp	Skin	
0	Unripe ...	0.79	1.60	12.3
1	Half ripe ...	0.65	1.01	56.3
2	" ..	0.79	..	67.5
6	"	0.62	1.03	105.0
7	Ripe	0.71	1.76	105.0
8	" ..	0.58	1.06	105.0
10	Fully ripe	0.60	0.91	86.3
Remaining mangoes were all placed in the cold room at 0 C				
12	Fully ripe .	0.77	1.57	101.3
14	"	0.61	1.11	108.0
17	Skin is damaged	0.93	0.12	115.0

TABLE III

*Badami mangoes plucked on 30th May 1938*

No of days after plucking	Description	Vitamin C in mgms per gram		Carotene mgms per kg
		Pulp	Skin	
1	Unripe . .	0.81	1.05	30.8
2	" .	0.64	1.92	32.0
3	" .	0.51	1.76	72.7
4	Half ripe	0.56	1.51	90.0
5	"	0.47	1.24	98.0
6	"	0.60	1.06	105.7
7	Ripe .	0.58	0.95	98.0
8	"	0.70	1.01	88.5
9	" .	0.86	1.19	112.5
Remaining mangoes were all placed in the cold room at 0°C				
11	Fully ripe	0.63	1.50	108.0
12	" .	0.64	1.07	108.0
13	" .	0.81	1.98	101.3
15	Skin is damaged	0.58	1.18	101.3

TABLE IV

*Malgou mangoes plucked on 11th June 1938.*

No. of days after plucking	Description	Vitamin C in mgms per gram.		Carotene mgms per kg
		Pulp	Skin	
2	Unripe . .	0.31	0.73	8.9
5	" ..	0.34	0.56	...
6	Ripe .	0.31	0.61	25.7
7	" ..	0.29	0.58	21.8
Remaining mangoes were all placed in the cold room at 0°C				
8	Ripe .	0.32	0.73	..
11	" ..	0.32	0.59	
13	" ..	0.28	0.68	
15	Fully ripe .	0.32	0.78	..
18	" .	0.21	0.92	
20	Damaged ..	0.25	0.83	...

*Season 1939* —Fifty Badami mangoes of almost the same size (200–300 gms) were carefully plucked from a tree in an orchard near Bangalore. Half of them were placed in the cold room at 0°C, and the rest were put in the ripening box under straw (temperature 21–28°C). A batch of the fresh mangoes were immediately analysed and on alternate days during the ripening the vitamin C content of the pulp was determined in three or four mangoes taken at random. The results are given in Table V.

TABLE V

*Badami Mangoes plucked on 3rd June 1939*

No of days after plucking	Description	Vitamin C in mgms per gm of the pulp	Mean
0	Unripe	0.96 0.95 0.91	0.94
2	"	1.09 0.78 0.99 0.83	0.92
4	Half ripe	0.77 0.56 0.77	0.70
6	"	0.73 0.59 0.59	0.64
9	Ripe	0.53 0.79 0.72	0.68
11	"	0.69 0.80 0.87	0.79
13	Fully ripe	0.74 0.98 0.89 0.71	0.83

The mangoes kept at 0°C for 17 days were taken out and placed in the ripening box at room temperature. The skin assumed a boiled green appearance, the pulp developed the smell of pickles.

and the mangoes did not ripen at all, showing that the cell activity had completely stopped. By the fourth day, fungus began to grow on the skin, softening and putrefaction were evident by the sixth day. The rapid fall in the vitamin C content of the pulp is shown by the results of analysis given in Table VI.

TABLE VI

*Badami mangoes plucked on 3rd June 1939 and kept at 0°C for 17 days*

No. of days at room temperature	Vitamin C in mgms per gm. of pulp	Mean
0	0.69	0.80
	0.95	
	0.76	
4	0.22	0.25
	0.38	
	0.15	
6	0.05	0.04
	0.03	
	0.05	

#### DISCUSSION AND CONCLUSIONS.

The results show a high range of variation in the vitamin C content of mangoes from the same tree ripened under identical conditions. Unfortunately, sufficient number of samples could not be analysed each day in the investigations of the 1938 season to obviate this difficulty and the vitamin C changes during ripening were not clearly brought out. The experiments of the 1939 season, however, indicate a fall in the ascorbic acid content of the pulp of the mango during the initial stages of ripening and a marked recovery after they reached the ripe stage. In order to get a comparative idea of the variations, the results of the three experiments with the Badami mangoes are summarised in Table VII.



TABLE VII

*Average values of the ascorbic acid content of Badami mangoes at various stages of ripening*

Stage of ripening	Ascorbic acid in mgms per gm					
	Pulp				Skin	
	May 1938 I	June 1938 II	June 1939 III	Mean of I, II & III	May 1938	June 1938
Unripe (0-3 days)	0.79	0.65	0.93	0.79	1.60	1.58
Half-ripe (4-6 days)	0.69	0.54	0.67	0.63	1.02	1.27
Ripe (7-10 days)	0.63	0.71	0.73	0.69	1.24	1.15
Fully ripe (11-17 days)	0.78 <sup>x</sup>	0.66 <sup>*</sup>	0.83	0.76	1.04 <sup>*</sup>	1.51 <sup>*</sup>

Kept in cold store during this period

A point of practical importance that comes out of this investigation is that there was no loss of vitamin C in the ripe mango fruits during storage at room temperature for five or six days and subsequent storage at 0°C for a fairly long time. Even in cases where rotting had set in near the skin of the mango, the healthy portions of the flesh were still rich in vitamin C. Green unripe mangoes kept in cold store at 0°C for some time and subsequently brought to room temperature did not ripen normally and the vitamin C content fell down rapidly.

Ascorbic acid content of the skin of the mango was two to three times that of the pulp. The individual variations were very high. It is likely that a certain amount of error was introduced by the varying amounts of the pulp that came off along with the skin.

Carotene content of the mango showed a definite and steady increase during ripening. The maximum value was reached by

about the sixth day of ripening. The variation in the carotene content of individual mangoes assayed on the same day was far less than that of their ascorbic acid content. The values were fairly even except in cases where the mangoes had suffered mechanical or other injury. Most of the xanthophyll (20 to 30 per cent of the total lipid pigments) was in the form of esters and the free xanthophyll content was always very low. Carotene development in the ripening fruit appears to run parallel to the carbohydrate changes from starch to sugars. It would be interesting to study the reserve material in the mature unripe mango that gives rise to carotene on ripening.

The practical use of these data lies in the fact that the processes of packing, transport and storage should be so regulated and adjusted that the fruit arrive at the market just at the half-ripe stage and that it must be consumed before the post-ripening changes set in.

#### SUMMARY

During the ripening of the mature mangoes at room temperature, there was an initial fall in the ascorbic acid content of the pulp towards the half-ripe stage followed by a recovery in the fully-ripe stage (green stage, 0.79, half-ripe, 0.63, ripe, 0.69 and fully-ripe, 0.76 mg per gm). There was no loss in the vitamin C content of the ripe fruit during storage for about a week at room temperature or for longer periods at 0°C. Mature mangoes which had sustained cold injury did not ripen when brought to room temperature, the vitamin C content fell down rapidly and carotene formation did not take place.

The ascorbic acid content of the skin was more than double that of the pulp.

There was a steady increase in the carotene content of the mango during ripening, the maximum value was reached by about the sixth day and this value was maintained for a fairly long time afterwards.

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[Received, 27.2.40]