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Biochemical characterization of hybrid progenies of mango (*Mangifera indica* L.)

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Abstract
The study was conducted 2015 to 2017 to find out "Biochemical Characterization of Hybrid Progenies of Mango (*Mangifera indica* L.)". The objective of the present investigation was to study the diversity of the hybrid derivatives at biochemical level. For this study forty-two hybrid derivatives of mango were selected from existing Germplasm. Regarding biochemical characters, hybrid-6 had the highest (20.85 °B) total soluble solids, the highest total sugar content was recorded in hybrid-26 (17.46%), highest reducing sugars in hybrid-8 (4.77%). The highest non-reducing sugar content was recorded in hybrid-26 (14.32%). The maximum acidity of pulp was recorded in hybrid-46 (0.45%), pH of pulp was recorded highest in hybrid-68 (4.90), Hybrid-1 revealed highest β-carotene content (2458.5 µg/100g); highest ascorbic acid content was recorded in hybrid-46 (37 mg/100g). TSS to acidity ratio was found highest in hybrid-35 (101.35) while a highest sugar to acidity ratio was recorded in hybrid-21 (83.47). The highest fibre content was recorded in hybrid-1 (0.97%).

Keywords: Biochemical, characterization, hybrid, progenies

Introduction
Mango (*Mangifera indica* L.) is the oldest and 'National fruit of India' and rightly known as 'King of fruits' owing to its nutritional richness, unique taste, pleasant aroma and religious and medicinal importance. Mango is believed to be originated to South East Asia, Indo-Burma region, in foot hills of the Himalayas (Mukherjee, 1951) [18]. Mango is second most important fruit crop which contributes 34.86 percent in area and 20.71 per cent in production, in total fruit crops grown all over India. It is being cultivated in India on 2515.97 thousand hectares area with an annual production of 18431.33 thousands MT along with productivity 7.3 MT/ha. India accounts for approximately 40 percent of total global mango production (Anon., 2016) [3].

Systematic characterization of physico-chemical characters of available germplasm provides the extent of genetic diversity in the fruits species and facilitate in identifying the superior genotype with desired characters. Morphological and biochemical markers are used on large scale for assessing genetic diversity in fruit crops but they show limited levels of detection of inter-varietal and intra-varietal polymorphisms on account of their environmental plasticity.

Research methods
The present investigation entitled "Biochemical Characterization of Hybrid Progenies of Mango (*Mangifera indica* L.)" was carried out during 2015-2017. For biochemical characterization, forty-two derivatives were selected from "Instructional-cum-Research Farm", Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri.

Biochemical characters
Total soluble solids (°Brix)
Total soluble solids (TSS) of pulp was estimated with the help of a hand refractometer calibrated in °Brix at 20 °C. (A.O.A.C., 1984).

Reducing sugars (%)
The reducing sugars were estimated by using Lane and Eynon (1923) [15] method with modification suggested by Ranganna (1997) [23]. A known weight (5 g) of sample was blended with distilled water using lead acetate (45%) for precipitation of extraneous material and potassium oxalate (22%) to delead the solution. This lead-free extract was used to estimate reducing sugars by stitrating against standard Fehling's mixture (Fehling's A and B) using

methylene blue as an indicator to a brick red end point.

Non-reducing sugars (%)
The non-reducing sugar content was determined by subtracting the value of reducing sugar from that of the total sugar and multiplying the values with 0.95 (as 0.95 g of sucrose on hydrolysis gives 1 g of monosaccharides i.e. glucose and fructose) and expressed as percentage (%).

Total sugars (%)
The total sugars were estimated by the same procedure of reducing sugars after acid hydrolysis of an aliquot of deleaded sample with 35 per cent hydrochloric acid, followed by neutralization with sodium hydroxide (40%). This filtrate was used for titration against standard Fehling's mixture (Fehling's A and B) using methylene blue as an indicator to brick red end point (Ranganna, 1997) [23].

Titratable acidity (%)
The titratable acidity was determined by titrating against standard alkali (N/10 NaOH) using phenolphthalein as an indicator and expressed as percentage (%) in terms of citric acid (A.O.A.C., 1984).

p^H of pulp
p^H of the pulp was recorded using p^H meter.

ß- carotene (µg/100g)
Total carotenoid pigments (expressed as β-carotene) were determined as per the method described by Roy and Susantha (1973) [26]. The results were expressed in terms of β-carotene as µg/100g sample.

Ascorbic acid content (mg/100g)
Determination of ascorbic acid was done by 2, 6-dichlorophenolindophenol dye method of Johnson (1948) [11] as described by Ranganna (1997) [23]. A known quantity of sample was blended with 3 per cent metaphosphoric acid (HPO_3) to make the final volume of 100 ml and then filtered. A known quantity of aliquot was titrated against 0.025 per cent 2, 6 - dichlorophenol indophenol dye to a pink colour end point. The ascorbic acid content of the sample was calculated taking into consideration the dye factor and expressed as mg ascorbic acid per 100g fruit pulp (Anon., 1966).

TSS: Acidity ratio
The ratio was calculated by dividing total soluble solids (TSS) by titratable acidity content of fruit.

Sugar: Acid ratio
The ratio was calculated by dividing total sugars by titratable acidity content of fruit.

Fibre (%)
The fibre content was determined from the fat free sample available in filter paper from fat extraction method (Ranganna, 1986) [24]. About 2-5 ml of moisture and fat free sample was weighed into 500 ml beaker and 200 ml of boiling 0.255 N sulphuric acid was added. The mixture was boiled for 30 mins. Keeping the volume constant by the addition of water at frequent intervals. At the end of this period, the mixture was filtered through a muslin cloth and the residue was washed with hot water till free from acid. The material was then transferred to the same beaker and 200 ml of boiling 0.313 N (1.25% NaOH) was added. Then sample was boiled for 30 mins., the mixture was filtered through muslin cloth. The residue was washed with hot water till free from alkali followed by washing with some alcohol and ether. It was then transferred to a crucible, dried overnight at 30 to 100 °C and weighed. The crucible was heated in a muffle furnace at 600 °C for 2-3 hours. Cooled, weighed again. The difference in the weight represents the weight of crude fibre. The results were expressed in percentage.

Research findings and Discussion
The results pertaining to the biochemical characterization of hybrid progenies of mango (*Mangifera indica* L.) are depicted as the pooled values obtained during two years i.e., 2015 to 2017.

1. Total soluble solids (°Brix)
The data presented in Table 1 revealed that among different derivatives TSS ranged 11.95 to 20.85 °B. Hybrid-6 had the highest total soluble solids (20.85 °B) whereas hybrid-13 recorded minimum TSS (11.95 °B).
These findings partially agreed with the results of Bhuyan and Guha (1995) [5], who also reported TSS from 16.22 to 24.14 °B in 14 mango germplasm under the climatic conditions of Rajshahi. Similar variation was also reported by Teaotia *et al*. (1972) and Samad *et al.* (1975) [27] in mango fruits. Variation in TSS (16.11 °B to 23.00 °B) is also reported by Singh (2002) [31]. The variation in TSS may be due to their varietal character.

2. Total sugars
The data presented in Table 1 showed great variation in total sugars. The total sugar content varied from 8.51 to 17.46 per cent. The highest total sugar content was recorded in hybrid-26 (17.46%) and the lowest was recorded in hybrid-2 (8.51%).
Total sugars have been found variable within the cultivars. Lodh *et al.* (1974) [16] obtained 7.35 to 13.20% total sugars in eight varieties of mango. Similarly, Singh (1968) [29] and Uddin *et al.* (2007) [34] recorded the variability for total sugars to the tune of 11.5 to 25% and 12.71 to 20.34% which might be due to genetic differences as well as agro-climatic conditions.

3. Reducing sugars
From the data presented in Table 1 showed notable difference in reducing sugar content of mango derivatives. The data revealed highest reducing sugar in hybrid-8 (4.77%) and lowest was recorded in hybrid-46 (1.03%).
Rathor *et al.* (2009) [25] recorded 3.8% reducing sugar in Dashehri. Uddin *et al.* (2007) [34] also reported lowest results regarding reducing sugars content ranged from 2.82 to 7.35%. Chaudhary *et al.* (1997) [6] reported 2.6 to 7.1% reducing sugar in 19 south Indian mango derivatives. Yadav *et al.* *(*1982) [35] reported maximum reducing sugars to the tune of 6.86% in Dashehri. The varieties having reducing sugars > 5.0% will be considered suitable for table purposes

4. Non-reducing sugars
It is evident from the data presented in Table 1 that the non-reducing sugars ranged from 5.66 to 14.32 percent. The highest non reducing sugar content was recorded in hybrid-26 (14.32%) and lowest was recorded in hybrid-2 (5.66%).
The highest value for non- reducing sugars was reported

(Syamal and Misra, 1987) as 11.5 percent in Langra. Radha *et al.* (1996) [21] reported that the non- reducing sugar content of Alphonso was 14.2 percent.

5. Titratable acidity

From the data presented in Table 1 the acidity of pulp ranged between 0.16 to 0.45 per cent. The maximum acidity of pulp was recorded in hybrid-46 (0.45%) and lowest was recorded in hybrid-35 (0.16%).

The values of titrable acidity are in accordance with the results of Kumar (1998) [13], who reported the range of 0.17 to 0.33% in different mango cultivars. Its wide range of values from 0.11 to 0.43% was also supported by Bakshi and Bajwa (1959) [4]. The variation in the acidity in the different varieties of mango could be due to their varietal characters.

6. p^H of pulp

The data regarding pH presented in Table 2 showed that the pH varied from 2.29 to 4.90. The pH of pulp was recorded highest in hybrid-68 (4.90) and lowest in hybrid-46 (2.29).

In mango, generally pH increased and acidity decreased from immature to mature and mature to ripened stages of fruit development. This statement can be better justified with the results of Pleguezuelo *et al*. (2012) [20]. They observed higher pH from 4.2 to 5.7 and lower titratable acidity from 0.05 to 0.22% from fruits of different cultivars harvested at maturity stage. Akhtar *et al*. (2010) [2] observed minimum pH lower than 4 and more acidity more than 0.60 in all four varieties including Dusheri, Chaunsa, Ratol and Langra fruits harvested even at maturity stage.

7. ß-carotene

The data presented in Table 2 showed that the β-carotene content in mango derivatives ranged from 1008.5 to 2458.5 μg/100g. Of all the derivatives hybrid-1 revealed highest β-carotene content (2458.5 μg/100g) and lowest was recorded in hybrid-46 (1008.5 μg/100g).

These findings are in agreement with observations made by Singh (2002) [31]. Variation in total carotenoids contents in the range of 2.33 mg/100 g - 44.95 mg/100 g was also recorded by Hoda *et al.* (2003) [10]. Total carotenoids provide an expression of natural appearance to the fruit product and their higher content in fruits offer distinct advantages, particularly in international trade where addition of artificial colour is discouraged.

8. Ascorbic acid content

It has been noticed from the Table 2 that the ascorbic acid content varied among different mango derivatives. The ascorbic acid content in mango fruits during investigation period ranged from 13 to 37 mg/100g. The highest ascorbic acid content was recorded in hybrid-46 (37 mg/100g) and the lowest was recorded in hybrid-55 (13 mg/100g).

A wide variation in ascorbic acid content (2.90 mg/100 g to 136.50 mg/100 g) has been reported by Doreyappa *et al.* (1994) [8]. Mitra *et al*. (2001) [17] observed the ascorbic acid content in the range of 21.66 mg/100 g to 125.40 mg/100 g. Such variation in ascorbic acid content could be attributed to the nature and extent of genetic variability present in the experimental material. These differences are supposed to be due to differential genetic makeup of the cultivars and also because of the differences in fruit development period and time of maturity. The variation in ascorbic acid content among mango cultivars is also reported by Rajwana *et al*. (2010) [22].

9. TSS: Acidity ratio

The data has been presented in Table 2 TSS to acidity ratio, as calculated by dividing the total soluble solids by titratable acidity elucidated remarkable differences and varied from 26.68 to 101.35. It was found highest in hybrid-35 (101.35) and lowest was recorded in hybrid-46 (26.68).

The results are contrary to the findings of Lodh *et al.* (1974) [16] who recorded TSS/Acidity ratio ranged from 5.50 to 109.20. Moreover, the TSS acidity ratios as reported in present study were similar to those of Palaniswamy *et al*. (1975) [19]. The similar findings have also been reported by Mitra *et al.* (2001) [17], Dhillon *et al*. (2004) [7], Sharma and Josan (1995) and Kher and Sharma (2002) [12] while working on fruit quality characters of different mango varieties under different climatic conditions. Kher and Sharma (2002) [12] and Hoda *et al.* (2003) [10] also reported the similar trend of variation i.e. 39.36 to 152.39 in different mango cultivars. Uddin *et al.* (2007) [34] also showed wide variation in TSS/Acidity ratio which ranged from 24.19 to 81.57.

10. Sugars: Acidity ratio

The data on sugars to acidity ratio, as calculated by dividing the total sugars by titratable acidity presented in Table 2 revealed noteworthy disparity in sugars to acidity ratio of mango derivatives however it ranged from 20.19 to 83.47. Highest sugars to acidity ratio was recorded in hybrid-21 (83.47) whereas lowest was recorded in hybrid-46 (20.19).

The Brix/acidity ratio is a balance between sugars and acids and is an indication of the palatability of the juice (Echeveria, 1990) [9].

11. Fibre

The data regarding fibre content in the fruit pulp presented in Table 2 ranged from 0.11 to 0.97 percent. The highest content was recorded in hybrid-1 (0.97%) whereas lowest was recorded in hybrid-2 (0.11%).

The fibre content was less in those varieties with high organoleptic acceptance. Consumer preference is for succulence and low fibre. Juicy and fibrous varieties are not suitable for canning (Lal *et al*. 1960) [14]. They are useful for making juice, squash, nectar, chutney and pickles. Fibrous nature of pulp is a wild character. Wild mangoes have fruits which are unacceptably fibrous (Singh, 1976) [30]. Fibre content ranged from 0.4 per cent (Nedungolan) to 2.92 (Natumavu Type-3). Fibre content was less (0.6%) in 14 varieties, while it was medium (0.6 to 0.9%) in 21 and high (0.9%) in 15 varieties (Simi, 2006).

Table 1: Pooled values of mango progenies for biochemical characters

Sr. No.	Genotypes	Total soluble solids (°B)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Titratable acidity (%)
1	Hybrid - 1	17.55	13.05	4.44	8.83	0.37
2	Hybrid - 2	12.05	8.51	3.00	5.66	0.28
3	Hybrid - 3	12.20	9.78	4.08	5.91	0.18

4	Hybrid - 4	18.15	14.32	4.23	10.30	0.25
5	Hybrid - 5	12.70	9.87	3.95	6.11	0.19
6	Hybrid - 6	20.85	16.68	4.52	12.39	0.22
7	Hybrid - 7	20.10	16.36	4.77	11.83	0.23
8	Hybrid - 8	18.05	12.70	3.72	9.17	0.28
9	Hybrid - 9	19.80	13.49	3.99	9.69	0.25
10	Hybrid - 10	19.25	17.20	3.89	13.51	0.28
11	Hybrid - 11	16.10	11.51	3.47	8.22	0.28
12	Hybrid - 12	18.50	15.66	3.29	12.53	0.28
13	Hybrid - 13	11.95	9.39	3.22	6.33	0.22
14	Hybrid - 14	14.80	8.95	3.12	5.98	0.25
15	Hybrid - 15	13.95	9.56	2.61	7.08	0.26
16	Hybrid - 16	16.60	12.37	2.29	10.20	0.23
17	Hybrid - 17	13.70	11.58	2.95	8.78	0.36
18	Hybrid - 18	16.80	12.36	2.00	10.46	0.19
19	Hybrid - 19	12.50	9.88	3.02	7.01	0.18
20	Hybrid - 20	12.20	9.23	1.27	8.03	0.25
21	Hybrid - 21	17.00	15.03	2.30	12.84	0.18
22	Hybrid - 22	15.75	13.36	1.56	11.88	0.19
23	Hybrid - 23	14.80	11.70	1.57	10.20	0.22
24	Hybrid - 24	16.20	12.68	1.43	11.32	0.18
25	Hybrid - 25	13.90	11.46	1.81	9.74	0.24
26	Hybrid - 26	18.75	17.46	3.31	14.32	0.25
27	Hybrid - 27	13.15	10.47	3.08	7.54	0.25
28	Hybrid - 28	13.00	11.91	2.94	9.12	0.24
29	Hybrid - 29	15.90	13.57	2.87	10.85	0.22
30	Hybrid - 30	14.85	12.86	3.07	9.94	0.22
31	Hybrid - 31	14.85	11.72	2.00	9.82	0.23
32	Hybrid - 32	15.20	11.84	2.14	9.80	0.24
33	Hybrid - 33	14.60	11.31	3.23	8.25	0.24
34	Hybrid - 34	15.50	13.49	2.52	11.10	0.19
35	Hybrid - 35	15.70	11.98	1.92	10.15	0.16
36	Hybrid - 36	16.60	13.26	2.66	10.73	0.21
37	Hybrid - 46	11.95	9.05	1.03	8.08	0.45
38	Hybrid - 52	18.70	17.40	3.99	13.61	0.25
39	Hybrid - 55	16.00	11.47	4.17	7.51	0.18
40	Hybrid - 56	15.30	12.78	3.30	9.64	0.22
41	Hybrid - 57	14.25	12.48	2.70	9.92	0.19
42	Hybrid - 68	15.20	13.13	2.93	10.34	0.17
	Range	11.95 - 20.85	8.51 - 17.46	1.03 - 4.77	5.66 - 14.32	0.16 - 0.45
	Mean	15.59	12.45	2.96	9.64	0.23
	Std.	2.41	2.37	0.95	2.20	0.06
	S.E. ±	0.37	0.37	0.15	0.34	0.01
	CV (%)	15.43	19.05	31.97	22.85	24.15

Table 2: Pooled values of mango progenies for biochemical characters

Sr. No.	Genotypes	pH of pulp	ß-carotene (µg/100ml pulp)	Ascorbic acid content (mg/100g)	TSS: Acidity ratio	Sugars: Acids ratio	Fibre (%)
1	Hybrid - 1	4.57	2458.5	33.0	47.65	35.44	0.97
2	Hybrid - 2	3.30	1126.5	26.0	43.84	30.93	0.11
3	Hybrid - 3	4.28	1896.5	22.5	69.75	55.92	0.63
4	Hybrid - 4	3.53	2389.0	23.5	74.12	58.43	0.23
5	Hybrid - 5	4.57	1602.5	31.0	68.64	53.36	0.30
6	Hybrid - 6	3.45	1849.0	27.0	97.01	77.64	0.31
7	Hybrid - 7	3.64	1835.5	35.5	87.39	71.11	0.36
8	Hybrid - 8	3.69	1198.5	24.0	64.49	45.47	0.23
9	Hybrid - 9	3.42	1061.5	27.0	79.33	53.97	0.24
10	Hybrid - 10	3.48	2129.0	19.0	70.00	62.57	0.35
11	Hybrid - 11	3.62	1130.0	30.0	58.84	42.00	0.27
12	Hybrid - 12	3.98	1766.5	28.0	66.10	55.97	0.47
13	Hybrid - 13	3.52	1101.5	24.5	56.22	44.14	0.58
14	Hybrid - 14	3.74	1316.0	22.0	60.50	36.52	0.36
15	Hybrid - 15	3.47	1266.5	20.5	54.76	37.46	0.44
16	Hybrid - 16	3.61	1162.0	21.0	72.33	53.89	0.50
17	Hybrid - 17	2.69	1245.5	17.0	38.59	32.62	0.24
18	Hybrid - 18	4.39	1342.0	17.5	90.98	66.86	0.65
19	Hybrid - 19	4.66	1333.5	15.0	69.50	55.05	0.71

20	Hybrid - 20	3.28	1212.0	17.0	49.79	37.68	0.43
21	Hybrid - 21	4.36	1186.5	15.0	94.44	83.47	0.36
22	Hybrid - 22	4.40	1017.0	25.0	85.31	72.30	0.48
23	Hybrid - 23	3.39	1025.5	29.0	68.96	54.45	0.46
24	Hybrid - 24	3.66	1255.0	25.0	90.00	70.44	0.39
25	Hybrid - 25	3.37	1390.0	23.0	59.26	48.79	0.28
26	Hybrid - 26	3.52	1545.0	23.5	75.24	69.97	0.85
27	Hybrid - 27	3.18	1074.5	15.5	52.63	41.93	0.24
28	Hybrid - 28	3.22	1171.5	18.0	55.36	50.70	0.37
29	Hybrid - 29	3.67	1319.5	13.0	73.96	63.18	0.44
30	Hybrid - 30	3.68	1269.5	15.5	67.51	58.43	0.22
31	Hybrid - 31	4.36	1146.0	19.5	66.04	52.11	0.27
32	Hybrid - 32	3.84	1395.0	21.5	63.33	49.31	0.80
33	Hybrid - 33	3.65	1027.0	20.0	62.10	48.14	0.88
34	Hybrid - 34	4.27	1320.5	21.5	81.81	71.08	0.20
35	Hybrid - 35	4.54	1291.5	14.5	101.35	77.23	0.17
36	Hybrid - 36	4.80	1341.0	16.0	79.05	63.14	0.74
37	Hybrid - 46	2.29	1008.5	37.0	26.68	20.19	0.13
38	Hybrid - 52	3.68	1676.5	17.0	75.00	69.69	0.16
39	Hybrid - 55	4.10	1283.5	13.0	88.89	63.69	0.28
40	Hybrid - 56	3.71	1139.5	14.5	71.23	59.47	0.38
41	Hybrid - 57	4.29	1100.5	20.5	77.12	67.53	0.64
42	Hybrid - 68	4.90	1262.0	25.0	92.21	79.58	0.25
	Range	2.29 - 4.9	1008.5 - 2458.5	13 - 37	26.68 - 101.35	20.19 - 83.47	0.11 - 0.97
	Mean	3.80	1372.49	22.06	69.70	55.76	0.41
	Std.	0.56	354.63	6.05	16.29	14.67	0.22
	S.E. ±	0.09	54.72	0.93	2.51	2.26	0.03
	CV (%)	14.72	25.84	27.43	23.38	26.31	52.69

References

1. AOAC. Official Method of Analysis. 14th Edition, Association of Official Agriculturist Chemist. Washington DC 1984, 16.
2. Akhtar S, Naz S, Mahmood S, Nasir M, Ahmad A. Physicochemical attributes and heavy metal content of mangoes (*Mangifera indica* L.) cultivated in different regions of Pakistan. Pak. J Bot 2010;42(4):2691-702.
3. Anonymous. FAO Statistics, Food and Agriculture Organization of the United Nations, Rome, Italy 2016. http://faostat.fao.org.
4. Bakshi JC, Bajwa BS. Studies on varietal differences in fruit quality of the mango varieties grown in the Punjab. Indian. J Hort 1959;16:216-220.
5. Bhuyan MAJ, Guha D. Performance of some exotic mango germplasm under Bangladesh conditions. Bangladesh J Hort 1995;23(1-2):17-22.
6. Chaudhary SM, Patil BT, Desai UT. Performance of South Indian mango varieties under semi-arid region of Maharashtra. J Maharashtra Agric. Uni 1997;22:72-74.
7. Dhillon WS, Sharma RC, Kahlon GS. Evaluation of some mango varieties under Punjab conditions. Haryana J Hort. Sci 2004;33(3-4):157-159.
8. Doreyappa ING, Ramanjaneya KH, Iyer CPA, Subramanyam MD, Dinesh MR. Physico-chemical and processing quality of four new Mango hybrids in comparison to two commercial cultivars. J Food Sci. and Technol 1994;31:385-388.
9. Echeveria E. Vacuolar acid hydrolysis as a physiological mechanism for sucrose breakdown. Plant Physiol 1990;90:530-533.
10. Hoda MN, Singh S, Singh J. Evaluation of ecological groups of mango (*Mangifera indica* L.) cultivars for flowering and fruiting under Bihar conditions. Indian J Agric. Sci 2003;73(2):101-105.
11. Johnson BC. Method of Vitamin 'C' determination. Burgess publ. Co., Minneapolis 1948, 98.
12. Kher R, Sharma RM. Performance of some mango cultivars under sub-tropical rainfed regions of Jammu. Haryana J Hort. Sci 2002;31(1/2):8-9.
13. Kumar N. Physico-chemical characteristics of some mango varieties under Bhagalpur (Bihar) conditions. Prog. Hort 1998;30:28-35.
14. Lal G, Siddappa GS, Tandon GL. Preservation of fruits and vegetable. Publication and information Division, ICAR, New Delhi 1960, 488.
15. Lane JH, Eynon L. Determination of reducing sugars by Fehling's solution with methylene blue as internal indicator. J Soc. Chem. Ind 1923;42:32.
16. Lodh SB, Subramanyam MD, Diwakar NG. Physico-chemicals studies of some important mango varieties. Indian J Hort 1974;31:160-161.
17. Mitra SS, Mitra SK. Studies on physico-chemical characteristics of nineteen mango varieties grown in West Bengal. Indian Agricst 2001;45:215-219.
18. Mukherjee SK. The origin of mango. Indian J Genet 1951;2:49.
19. Palaniswamy KP, Muthukrishnan CR, Shanmugavelu KG. Physico-chemical characteristics of some varieties of mango. Indian Food Packer 1975;28(4):12-19.
20. Pleguezuelo CRR, Zuazo VHD, Fernandez JLM, Tarifa DF. Physico-chemical quality parameters of mango (*Mangifera indica* L.) fruits grown in a Mediterranean subtropical climate (SE Spain). J Agri. Sci. Tech 2012;14:365-74.
21. Radha T, Nair SR, Sreejaya KC. Physicochemical analysis of Alphonso and Bangalora varieties of mango. J Trop. Agric 1996;34:145-146.
22. Rajwana IA, Malik AU, Khan AS, Saleem BA, Malik SA. A new mango hybrid shows better shelf life and fruit quality. Pakistan J Bot 2010;42(4):2503-2512.
23. Ranganna S. Handbook of Analysis and Quality Controls for Fruits and Vegetables Products, 2nd ed. Tata McGraw Hill Co. Ltd., New Delhi 1977.

24. Ranganna S. Manual of analysis of fruit and vegetable products. Tata-Mc Graw Hill publishing Co. Ltd. New Delhi 1986, 12-109.
25. Rathor CS, Singh R, Singh SK, Srivastav M. Evaluation and correlation studies in mango genotypes under-north Indian conditions. Indian J Hort 2009;66(3):374-378.
26. Roy T, Susantha K. Simple and rapid method for estimation of total carotenoid pigment in mango. J Fd. Sci. and Tecnol 1973;10(1):46.
27. Samad MA, Faruque HM, Malek MA. A study on the biochemical characteristics of fruits of some common varieties of Bangladesh. Bangladesh Hort 1975;3:28-32.
28. Sharma JN, Josan JS, Thind SK, Arora PK. Evaluation of mango cultivars for arid-irrigated region of Punjab. J Appl. Hort 1999;1(2):103-104.
29. Singh LB. The Mango: Botany, Cultivation and Utilization. Leonard Hill, London 1968, 438.
30. Singh LB. Mango. Evolution of Crop Plants. (ed. Simmonds, N.W.) Longman Group Pvt. Ltd., London 1976, 7-9.
31. Singh S. Evaluation of mango cultivars for their flowering, fruiting and fruit quality attributes. Prog. Hort 2002;34(2):240-243.
32. Syamal MM, Mishra KA. Physico-chemical analysis of some important mango varieties of Bihar. Acta Hort 1989;231:149-151.
33. Teotia SS, Singh RD, Aswathi RK. Studies on mango varieties: morphological and physico-chemical studies of some important table varieties. Punjab Hort. J 1972;12:153-0157.
34. Uddin MZ, Mortuza MG, Alam MA, Islam MS, Uddin MS. Performance of some commercial and promising mango varieties. J Bangladesh Soc. Agric. Sci. Technol 2007;4(1&2):105-108.
35. Yadav SA, Prasad A, Abidi AB. Biochemical studies in mango fruits. Prog. Hort 1982;14(1):51-53.