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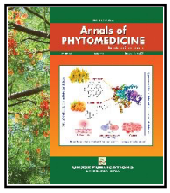

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Studies on extent of genetic diversity among the mango, *Mangifera indica* (L.) germplasm by using biochemical characters

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Abstract

The investigation entitled studies on extent of genetic diversity among the mango germplasm by using biochemical characters was carried out during the period 2021-2022 and 2022-23 at Mango Research Station, Nuzvid, Eluru District, Andhra pradesh. In the present study 36 genotypes and 4 checks, *viz*., Banaganapalle, Chinnarasam, Jalal and Suvarnarekha were evaluated for various biochemical characters. The TSS ranged from 7.88 °Brix to 20.93 °Brix with a mean value of 13.48 °Brix, titrable acidity (%) among the genotypes varied significantly from 0.14% to 0.47% with a mean value of 0.32%. TSS: acid ratio ranged from 16.59 to 149.46 with a mean value of 48.00, the total sugars ranged from 4.75% to 17.48% with a mean value of 9.10%, reducing sugars among the genotypes varied significantly from 1.40% (F-4) to 6.82% (B-9), with a mean value of 3.64%, non-reducing sugars ranged from 2.36% to 10.66% with a mean value of 5.46%, the ascorbic acid ranged from 21.73 mg/100 g (B-9) to 52.01 mg/100 g (H-5) with a mean value of 36.32 mg/100 g, total phenols content ranged from 53.22 mg of gallic acid/100 g (Chinnarasam) to 134.52 mg of gallic acid/100 g (H-5) with a mean value of 91.38 mg of gallic acid/100 g and β-carotene content among the genotypes varied significantly from 685.50 µg/100 g to 1942.11 µg/100 g, with a mean value of 1289.79 µg/100 g.

1. Introduction

Mango (*Mangifera indica* L.) is the most nutritive and delicious fruit crop belonging to the Anacardiaceae family and originated in Indo-Burma region. Due to its popularity and importance, mango is often named 'King of fruits' for its luscious flavour and taste. It is recognized as the pride fruit of India, being the richest source of vitamin A (4800 I.U.), vitamin C, minerals and other nutrients (Bhamini *et al*., 2018). In India, mango is cultivated in an area of 2325 thousand hectares with production of 208.99 lakh tonnes and 9.0 MT/ha productivity. The major mango-growing states in India encompass Uttar Pradesh, Karnataka, Andhra pradesh, Telangana, Bihar, West Bengal and Gujarat, *etc*. Notably, in Andhra pradesh, it is cultivated in an area of 378.94 thousand ha, yielding a production of 4926.22 MT and productivity of 13 MT/ha (NHB Data base, 2020-21).

Nowadays, particular attention is paid to nutrients capable of counteracting oxidative stress. A certain number of reactive oxygen species, or ROS, including superoxide anions, hydroxyls, and hydrogen peroxide, are produced in the human body. Some of them, such as superoxide anions and hydrogen peroxide, are physiologically generated during the electron transfer in the mitochondrial respiratory chain. Other species, as the hydroxyl radical, one of the more dangerous ROS, is produced by the Fenton reaction, causing the oxidation of Fe^{2+} to Fe^{3+}. These derivatives of oxygen, highly unstable and particularly reactive, oxidize atoms or organic molecules, especially cell components such as proteins, lipids, and nucleic acids.

Cells have developed a specific group of enzymatic systems (catalase, superoxide dismutase, glutathione peroxidase, *etc*.) to remove ROS and many of them are transcriptionally regulated by Nrf2 (nuclear factor erythroid 2-related factor 2)/Keap-1 (Kelch-like ECH-associated protein 1) axis, the master regulatory pathway of the antioxidant response (Ahmed *et al*., 2017). Under stress conditions, Nrf2 is stabilized and allows survival and stress adaptation, upregulating the expression of some cytoprotective molecules, the antioxidant responses, and the stress-mediated detoxification enzymes (NAD(P)H quinina reductase, glutathione S-transferase, superoxide dismutase, heme oxygenase, catalase, and glutathione peroxidase). If, ROS are not removed, their accumulation overcomes the cellular reparative abilities, causing the collapse of cellular functions and can result in the generation of pathological states related to aging, cancer, atherosclerosis, heart attack, stroke, and diabetes (Done and *Traustadottir*, 2016).

It is well known that phytochemical compounds of a phenolic nature commonly found in fruits display free radical scavenging activities, due to the reactivity of the phenol moiety and *via* hydrogen or electron donation. The large variety of antioxidants, pigments, and vitamins that are present in any part of the mango plant are responsible for the antioxidant and free radical scavenging activities.

Mangoes are a popular stone fruit commonly eaten throughout the world. It is rich in antioxidants, such as ascorbic acid , carotenoids, and polyphenols. Several studies showed that phytochemicals contained in mango play an anti-inflammatory role in several chronic pathological disorders associated with inflammatory responses. Bioactive compounds of mango have been also reported to exert

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antidiabetic effects, anticancer activity in different tumour cell lines, cardiovascular diseases, ageing, and neurodegenerative disorders (Dhananjaya and Shivalingaiah, 2016). Given the antioxidant-rich profile of mango, this study aims to identify and quantify these beneficial compounds that are crucial for human health.

2. Materials and Methods

The experiment was conducted to "study the extent of genetic diversity among the mango germplasm by using biochemical characters. The experiment was laid out in an Augmented Block Design consisting of 36 genotypes and 4 checks, *viz*., Banaganapalle, Chinnarasam, Jalal and Suvarnarekha (Figure 1). The details of genotypes are furnished in Table 1. Genotypes are named as per the names of the blocks, *i.e.,* B, C, D, E, F, G, H and I. All the phytochemical analyses were carried out in three replications in the biochemistry lab, Mango Research Station, Nuzvid.

Figure 1: General view of experimental site.

Table 1: List of 36 genotypes and 4 checks used in the study.

S.No.	Genotype	S.No.	Genotype
1	B-6	21	F-16
2	B-9	22	G-7
3	B-10	23	G-19
4	B-17	24	G-28
5	B-20	25	G-30
6	C-1	26	H-5
7	C-6	27	H-7
8	C-13	28	H-16
9	C-24	29	H-17
10	D-7	30	H-32
11	D-12	31	H-49
12	D-13	32	H-58
13	E-2	33	I-1
14	E-3	34	I-2
15	E-6	35	I-3
16	E-8	36	I-4
17	E-11	37	Banaganapalle (Table variety)
18	F-4	38	Chinnarasam (Juicy variety)
19	F-10	39	Jalal (Pickle variety)
20	F-12	40	Suvarnarekha (Coloured variety)

2.1 Phytochemical analysis

2.1.1 Total soluble solids (TSS)

The percentage of total soluble solids was determined by using ERMA hand refractrometer by placing a drop of filtered juice on the prism of the refractrometer and observed the coincidence of shadow of the sample with the reading on the scale and expressed as ºBrix. Before taking the reading, the refractrometer was tested for its error with distilled water, corrected accordingly and TSS content was recorded (Ranganna, 1986).

2.1.2 Titrable acidity (%)

10 ml of homogenized sample was taken and made up to 100 ml volume with distilled water in a volumetric flask. The contents were filtered through Whatman No.1 filter paper. An aliquot of 10 ml was taken in 250 ml conical flask for titration against 0.1N NaOH by using phenolphthalein as an indicator. The turn of aliquot to light pink colour which persists for 15 sec was considered as an end point and the titratable acidity was estimated in terms of per cent citric acid (Ranganna, 1986).

2.1.3 TSS: acid ratio

The ratio was calculated by dividing TSS with the acidity.

2.1.4 Total sugars (%)

Total sugars were determined as procedure described by Lane and Eyon method (AOAC, 1965). A quantity of 50 ml lead free filtrate was taken in a 100 ml volumetric flask and to it 5 ml of concentrated HCl was added, mixed well and then kept for 24 h at room temperature. Acid was then neutralized with NaOH by using a drop of phenolphthalein as an indicator till the pink color persisted for at least few seconds. Then volume was made up to 100 ml. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) by using methylene blue as an indicator and taking brick red colour as an end point.

2.1.5 Reducing sugars (%)

Reducing sugars were determined by Lane and Eyon method (AOAC, 1965). 25 ml of fruit juice was taken and transferred to 250 ml volumetric flask. 2 ml of lead acetate solution (45%) was added to flask for precipitation of colloidal matter. Potassium oxalate (22%) of 2 ml was added in this solution to precipitate the lead and the volume made up to 250 ml using distilled water.

The contents were then filtered through Whatman No. 1 filter paper after testing a little of filtrate for its freedom from lead by adding a drop of potassium oxalate. Reducing sugars in the lead free solution was taken in burette and titrated against 10 ml of standard Fehling's solution mixture of A and B (1: 1) by using methylene blue as an indicator till the end point was indicated by the formation of brick red precipitate.The titration was carried out by keeping the Fehling's solution boiling on the heating mantle.

2.1.6 Non-reducing sugars (%)

Non-reducing sugars in juice was obtained by subtracting reducing sugars from total sugars.

2.1.7 Ascorbic acid (mg /100 g)

10 g of mango pulp was blended with metaphosphoric acid (3% HPO_3) and volume was made up to 100 ml with HPO_3 (3%).The content after shaking well was filtered through Whatman No.1 filter paper. 10 ml of filtrate was titrated against 2,6 dichlorophenol-indophenol dye until light pink colour was observed (AOAC, 1965).

2.1.8 Total phenols content (mg of gallic acid /100 g)

Phenols were estimated according to the procedure given by Malik and Singh (1980). 1 g of sample was extracted with 10 ml of 80 per cent methanol. The homogenated extracts were centrifuged at 10,000 rpm for 20 min and the supernatant saved was evaporated to dryness in a water bath. The residue was dissolved in 5 ml of distilled water and then 0.5 ml of Folin - Ciocalteau's reagent (1N) was added. To that, 2 ml of sodium carbonate (20%) solution was added and after mixing thoroughly the tubes were placed in boiling water for one minute, cooled and the absorbance was measured at 650 nm by using spectrophotometer.

Standard curve was drawn by using gallic acid as standard. Different concentrations of gallic acid were prepared and O.D was read at 650 nm. The concentration of samples was calculated based on the standard curve.

2.1.9 β-carotene (µg/100 g)

6 g of fresh sample was weighed with the help of electronic balance and crushed with 10-15 ml of acetone and a few crystals of anhydrous sodium sulphate, with the help of mortar and pestle. Decant the supernatant into a beaker. Repeat the process twice and transfer the combined supernatant sample into a separatory funnel, 10-15 ml petroleum ether was added and mixed thoroughly. Two layers were separated. Discard the lower layer and collect the upper layer into a 100 ml volumetric flask, made up the volume to 100 ml with petroleum ether and record the optical density at 425 nm by usingspectrophotometer as petroleum ether as blank (Srivastava and Sanjeev, 2014).

3. Results

Mean performance of 36 mango genotypes and 4 checks, *viz*., Banaganapalle, Chinnarasam, Jalal and Suvarnarekha for various biochemical characters are presented in (Tables 2, 3 and 4).

3.1 Total soluble solids (TSS)

Considerable variation was observed with respect to TSS. The TSS ranged from 7.88 °Brix to 20.93 °Brix with a mean value of13.48 °Brix and twenty two genotypes were found to possess higher TSS over the mean. Among the 40 genotypes evaluated, only one genotype, *i.e.,* B-9 (20.93 °Brix) recorded a significantly higher TSS than the best check Chinnarasam (17.91 °Brix), which was maximum among the checks. The lower TSS was recorded in F-4 (7.88 °Brix). Similar results were reported by Aswini and Bhaskar (2023) and Muniyappan *et al*. (2023) they stated that TSS ranged from 14.78 to 26.77 p Brix and 13.20 to 22.70 p Brix, respectively, in mango.

3.2 Titrable acidity (%)

Titrable acidity (%) among the genotypes varied significantly from 0.14% to 0.47%, with a mean value of 0.32% and seventeen genotypes were found to possess lower titrable acidity over the mean. Among the genotypes studied, one genotype, *i.e.,* B-9 (0.14%)

recorded significantly lower titrable acidity than the best check Chinnarasam (0.18%), which was minimum among the checks. The higher titrable acidity was recorded in D-7 and F-4 (0.47%). These results are in agreement with the findings of Islam *et al*. (2019) and Saroj *et al*. (2023) with respect to titrable acidity which ranged from 0.13 to 0.39% and 0.12 to 0.37%, respectively, in their studies in mango.

3.3 TSS: acid ratio

Significant variation was observed in the TSS: acid ratio among the genotypes studied. It ranged from 16.59 to 149.46 with a mean value of 48.00 and thirteen genotypes exceeded the general mean value. Among the genotypes, one genotype, *i.e.,* B-9 (149.46) recorded a significantly higher TSS: acid ratio compared to the check Chinnarasam, which recorded the higher TSS: acid ratio among checks (99.52). The lower TSS: acid ratio was recorded in F-4 (16.59). Similar range of TSS: acid ratio (15.64 to 191.12) was reported by Sridhar *et al*. (2018) in mango.

3.4 Total sugars (%)

There were significant differences among genotypes with respect to total sugars. It ranged from 4.75% to 17.48%. The mean total sugars recorded was 9.10% and seventeen genotypes had higher total sugars than the general mean. Among the genotypes studied, one genotype, *i.e.,* B-9 (17.48%) recorded significantly higher total sugars compared to the check Chinnarasam (15.55%), which was maximum among the checks. The lower total sugars was recorded in D-7 (4.75%). Similar findings were reported by Sridhar *et al*. (2018) with respect to total sugars which ranged from 8.58 to 14.57% in mango.

3.5 Reducing sugars (%)

Reducing sugars among the genotypes varied significantly from 1.40% (F-4) to 6.82% (B-9), with a mean value of 3.64% and twenty two genotypes exceeded the general mean value. Among the genotypes evaluated, one genotype, *i.e.,* B-9 (6.82%) recorded significantly higher reducing sugars than the best check Chinnarasam (6.60%) which was maximum among the checks. These results were in agreement with the findings of Singh *et al*. (2012) who reported that reducing sugars ranged from 2.15 to 5.33% in mango.

3.6 Non-reducing sugars (%)

Non-reducing sugars ranged from 2.36% to 10.66% with a mean value of 5.46% and eighteen genotypes were found to possess higher non-reducing sugars over the mean, indicating significant variability among the genotypes. Among the genotypes evaluated three genotypes, *viz*., B-9 (10.66%), E-2 (10.28%) and C-6 (9.39%) recorded significantly highest non-reducing sugars compared to the best check Chinnarasam (8.95%) which was maximum among the checks. The lowest value was recorded in F-10 (2.36%). Similar range of non-reducing sugars (4.46 to 11.08%) was reported by Singh *et al*. (2012) in mango.

3.7 Ascorbic acid (mg/100 g)

Significant variation was observed with respect to ascorbic acid. The ascorbic acid ranged from 21.73 mg/100 g (B-9) to 52.01 mg/100 g (H-5) with a mean value of 36.32 mg/100 g and eighteen genotypes had higher ascorbic acid than the general mean. Among the genotypes evaluated, eighteen genotypes, *viz*., H-5 (52.01 mg/100 g), F-12 (48.27 mg/100 g), D-7 (46.48 mg/100 g), F-10 (46.09 mg/100 g), G-30 (43.40 mg/100 g), E-6 (42.53 mg/100 g), H-16 (41.82 mg/100 g), C-13 (41.55 mg/100 g), G-7 (41.14 mg/100 g), D-12 (40.98 mg/100 g), I-2 (40.45 mg/100 g), H-49 (40.25 mg/100 g), B-17 (39.36 mg/100 g), G-28 (38.98 mg/100 g), C-24 (38.66 mg/100 g), H-17 (38.60 mg/100 g), F-4 (38.28 mg/100 g) and E-3 (37.61 mg/100 g) recorded a significantly higher ascorbic acid than the best check Chinnarasam (35.34 mg/100 g) which was maximum among the checks. The lower ascorbic acid was recorded in B-9 (21.73 mg/100 g). Similar findings were reported by Aswini and Bhaskar (2023) and Muniyappan *et al*. (2023) they stated that ascorbic acid content ranged from 28.26 to 79.68 mg/100 g and 16.85 to 52.08 mg/100 g, respectively, in mango.

3.8 Total phenols content (mg of gallic acid/100 g)

There were significant differences among genotypes with respect to total phenols content. It ranged from 53.22 mg of gallic acid/100 g (Chinnarasam) to 134.52 mg of gallic acid/100 g (H-5). The mean total phenols content recorded was 91.38 mg of gallic acid/100 g and nineteen genotypes were found to possess lower total phenols content over the mean. None of the genotypes recorded lower total phenols content than the check Chinnarasam (53.22 mg of gallic acid/100 g), which was minimum among the checks. Similar findings were reported by Saroj *et al*. (2023) with respect to total phenols content which ranged from 297.50 to 560.60 µg/100 g in mango.

3.9 β-carotene (µg/100 g)

β-carotene content among the genotypes varied significantly from 685.50 µg/100 g to 1942.11 µg/100 g, with a mean value of 1289.79 µg/100 g and nineteen genotypes were found to possess higher β-carotene over the mean. None of the genotypes recorded higher β-carotene than the check Banaganapalle (1942.11 µg/100 g) which was maximum among the checks. The lower β- carotene was recorded in F-4 (685.50 µg/100 g). Similar results were reported by Islam *et al*. (2019) who stated that â-carotene ranged from 213 to 538 µg/100 g in mango.

Table 2: Mean performance of mango genotypes for total soluble solids (TSS), titrable acidity (%) and TSS: acid ratio

S.No.	Accessions	Total soluble solids (TSS)			Titrable acidity (%)			TSS: acid ratio		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
1.	B-6	14.56	14.09	14.33	0.32	0.30	0.31	45.50	46.97	46.23
2.	B-9	20.29	21.56	20.93	0.14	0.14	0.14	144.92	154.00	149.46
3.	B-10	16.43	16.48	16.45	0.28	0.27	0.28	58.67	61.03	59.85
4.	B-17	12.87	14.34	13.61	0.34	0.32	0.33	37.85	44.81	41.33
5.	B-20	15.92	14.26	15.09	0.26	0.25	0.25	61.23	57.04	59.14

6.	C-1	16.29	17.32	16.81	0.28	0.28	0.28	58.17	61.86	60.01
7.	C-6	16.56	16.84	16.70	0.24	0.23	0.23	69.00	73.22	71.11
8.	C-13	10.39	12.49	11.44	0.39	0.37	0.38	26.64	33.76	30.20
9.	C-24	11.75	10.58	11.17	0.36	0.36	0.36	32.63	29.39	31.01
10.	D-7	9.58	10.04	9.81	0.45	0.49	0.47	21.28	20.49	20.89
11.	D-12	10.28	11.52	10.90	0.41	0.41	0.41	25.07	28.10	26.58
12.	D-13	12.35	14.39	13.37	0.32	0.30	0.31	38.59	47.97	43.28
13.	E-2	17.18	15.84	16.51	0.18	0.19	0.18	95.44	83.37	89.40
14.	E-3	14.26	14.19	14.23	0.33	0.30	0.31	43.21	47.30	45.25
15.	E-6	11.10	12.52	11.81	0.35	0.35	0.35	31.71	35.77	33.74
16.	E-8	13.36	15.26	14.31	0.34	0.32	0.33	39.29	47.69	43.49
17.	E-11	14.52	14.69	14.61	0.31	0.31	0.31	46.83	47.39	47.11
18.	F-4	7.67	8.09	7.88	0.48	0.47	0.47	15.97	17.21	16.59
19.	F-10	9.86	11.25	10.56	0.40	0.37	0.39	24.65	30.41	27.53
20.	F-12	9.79	9.56	9.67	0.42	0.42	0.42	23.30	22.76	23.03
21.	F-16	18.32	16.32	17.32	0.17	0.19	0.18	107.76	85.89	96.83
22.	G-7	11.19	11.05	11.12	0.38	0.36	0.37	29.44	30.69	30.07
23.	G-19	15.98	17.68	16.83	0.32	0.31	0.32	49.93	57.03	53.48
24.	G-28	11.42	11.29	11.36	0.36	0.35	0.35	31.72	32.26	31.99
25.	G-30	10.26	9.44	9.85	0.39	0.42	0.40	26.30	22.48	24.39
26.	H-5	9.37	10.05	9.71	0.43	0.46	0.45	21.79	21.85	21.82
27.	H-7	14.46	14.78	14.62	0.34	0.34	0.34	42.52	43.47	43.00
28.	H-16	10.69	10.25	10.47	0.37	0.38	0.37	28.89	26.97	27.93
29.	H-17	13.29	15.64	14.46	0.34	0.32	0.33	39.08	48.87	43.98
30.	H-32	16.14	16.58	16.36	0.19	0.22	0.21	84.94	75.36	80.15
31.	H-49	10.37	10.95	10.66	0.36	0.36	0.36	28.80	30.42	29.61
32.	H-58	11.64	10.39	11.01	0.33	0.35	0.34	35.27	29.68	32.48
33.	I-1	14.32	15.05	14.69	0.32	0.30	0.31	44.75	50.16	47.46
34.	I-2	11.49	11.16	11.32	0.38	0.35	0.37	30.23	31.89	31.06
35.	I-3	14.25	16.39	15.32	0.30	0.32	0.31	47.50	51.22	49.36
36.	I-4	15.53	15.04	15.28	0.31	0.34	0.33	50.09	44.23	47.16
37.	Banaganapalle	16.18	16.92	16.55	0.23	0.21	0.22	70.34	80.57	75.46
38.	Chinnarasam	17.35	18.48	17.91	0.18	0.18	0.18	96.38	102.67	99.52
39.	Jalal	8.22	9.64	8.93	0.46	0.45	0.46	17.86	21.42	19.64
40.	Suvarnarekha	15.31	14.89	15.10	0.20	0.24	0.22	76.55	62.04	69.30
	Mean			**13.48**			**0.32**			**48.00**
	CD @ 5%			**0.42**			**0.01**			**1.55**
	SEM (±)			**0.15**			**0.004**			**0.55**

Table 3: Mean performance of mango genotypes for total sugars (%), reducing sugars (%) and non-reducing sugars (%)

S.No.	Accessions	Total sugars (%)			Reducing sugars (%)			Non-reducing sugars (%)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
1.	B-6	9.62	8.45	9.04	3.26	5.09	4.18	6.36	3.36	4.86
2.	B-9	16.39	18.57	17.48	6.52	7.12	6.82	9.87	11.45	10.66
3.	B-10	11.16	12.04	11.60	4.59	4.25	4.42	6.57	7.79	7.18
4.	B-17	8.14	8.38	8.26	2.32	3.04	2.68	5.82	5.34	5.58
5.	B-20	9.94	10.26	10.10	3.39	4.16	3.77	6.55	6.10	6.33
6.	C-1	11.06	9.54	10.30	4.62	5.48	5.05	6.44	4.06	5.25
7.	C-6	12.42	14.78	13.60	3.84	4.59	4.22	8.58	10.19	9.39
8.	C-13	6.29	6.05	6.17	2.94	2.27	2.61	3.35	3.78	3.57
9.	C-24	6.62	7.59	7.11	3.09	5.15	4.12	3.53	2.44	2.98
10.	D-7	5.12	4.37	4.75	1.86	1.62	1.74	3.26	2.75	3.01
11.	D-12	5.89	6.25	6.07	2.37	3.08	2.73	3.52	3.17	3.34
12.	D-13	7.36	8.02	7.69	2.46	2.75	2.61	4.90	5.27	5.09
13.	E-2	13.59	15.54	14.57	4.96	3.62	4.29	8.63	11.92	10.28
14.	E-3	8.92	9.36	9.14	3.14	4.05	3.60	5.78	5.31	5.54
15.	E-6	6.32	5.58	5.95	2.64	2.49	2.56	3.68	3.09	3.39
16.	E-8	9.08	10.44	9.76	2.85	3.16	3.00	6.23	7.28	6.75
17.	E-11	9.24	8.96	9.10	3.18	5.02	4.10	6.06	3.94	5.00
18.	F-4	4.59	5.05	4.82	1.25	1.54	1.40	3.34	3.51	3.42
19.	F-10	5.94	5.17	5.56	2.53	3.86	3.19	3.41	1.31	2.36
20.	F-12	6.14	8.29	7.22	2.49	2.15	2.32	3.65	6.14	4.89
21.	F-16	14.83	15.62	15.22	5.94	6.03	5.99	8.89	9.59	9.24
22.	G-7	6.45	5.87	6.16	2.18	2.56	2.37	4.27	3.31	3.79
23.	G-19	10.56	10.02	10.29	4.12	3.89	4.01	6.44	6.13	6.28
24.	G-28	6.59	7.24	6.92	3.14	4.05	3.60	3.45	3.19	3.32
25.	G-30	6.24	6.71	6.47	2.68	2.17	2.43	3.56	4.54	4.05
26.	H-5	4.96	5.05	5.00	1.59	2.04	1.81	3.37	3.01	3.19
27.	H-7	9.12	11.39	10.25	3.68	5.16	4.42	5.44	6.23	5.83
28.	H-16	6.41	7.18	6.80	3.17	4.25	3.71	3.24	2.93	3.08
29.	H-17	8.59	8.94	8.77	3.28	2.63	2.96	5.31	6.31	5.81
30.	H-32	12.45	11.27	11.86	4.02	5.54	4.78	8.43	5.73	7.08
31.	H-49	7.54	8.39	7.97	2.96	3.05	3.00	4.58	5.34	4.96
32.	H-58	6.82	5.63	6.23	3.59	3.82	3.70	3.23	1.81	2.52
33.	I-1	10.02	10.85	10.43	4.97	3.24	4.11	5.05	7.61	6.33
34.	I-2	7.18	8.07	7.62	3.36	4.59	3.98	3.82	3.48	3.65
35.	I-3	9.64	8.42	9.03	4.02	4.22	4.12	5.62	4.20	4.91
36.	I-4	10.59	10.26	10.43	4.61	3.54	4.08	5.98	6.72	6.35
37.	Banaganapalle	12.82	14.49	13.66	4.18	5.26	4.72	8.64	9.23	8.94
38.	Chinnarasam	15.86	15.24	15.55	6.34	6.85	6.60	9.52	8.39	8.95
39.	Jalal	5.09	6.47	5.78	1.94	1.04	1.49	3.15	5.43	4.29
40.	Suvarnarekha	11.58	11.05	11.32	4.45	3.92	4.18	7.13	7.13	7.13
	Mean			**9.10**			**3.64**			**5.46**
	CD @ 5%			**0.29**			**0.10**			**0.30**
	SEM (±)			**0.10**			**0.04**			**0.11**

Table 4: Mean performance of mango genotypes for ascorbic acid (mg/100 g), total phenols content (mg of gallic acid/100 g) and β-carotene (µg/100 g)

S.No.	Accessions	Ascorbic acid (mg/100 g)			Total phenols content (mg of gallic acid/100 g)			β-carotene (µg/100 g)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
1.	B-6	32.59	38.56	35.57	106.49	110.62	108.55	1346.20	1495.65	1420.93
2.	B-9	22.36	21.09	21.73	82.30	76.54	79.42	1862.42	1653.29	1757.85
3.	B-10	30.45	30.68	30.57	65.24	67.18	66.21	1594.59	1479.84	1537.21
4.	B-17	38.57	40.15	39.36	128.65	128.04	128.35	1063.26	1024.64	1043.95
5.	B-20	26.08	24.82	25.45	96.02	98.38	97.20	1955.14	1763.22	1859.18
6.	C-1	28.72	29.56	29.14	62.19	58.46	60.33	1493.89	1524.52	1509.20
7.	C-6	34.56	34.29	34.42	104.02	109.24	106.63	1655.65	1647.39	1651.52
8.	C-13	42.49	40.61	41.55	75.96	69.43	72.69	1082.16	1125.94	1104.05
9.	C-24	38.06	39.25	38.66	89.64	91.36	90.50	1158.54	1206.90	1182.72
10.	D-7	45.32	47.65	46.48	122.48	126.72	124.60	942.06	1063.74	1002.90
11.	D-12	39.92	42.04	40.98	95.26	97.15	96.20	1187.25	1152.59	1169.92
12.	D-13	36.49	34.52	35.50	114.58	106.32	110.45	1292.98	1345.62	1319.30
13.	E-2	28.64	29.26	28.95	76.82	79.16	77.99	1724.72	1701.56	1713.14
14.	E-3	36.87	38.34	37.61	90.05	94.29	92.17	1468.56	1423.79	1446.17
15.	E-6	42.92	42.15	42.53	69.98	62.43	66.21	1091.69	1105.94	1098.82
16.	E-8	34.09	35.37	34.73	119.46	124.21	121.84	1235.74	1182.36	1209.05
17.	E-11	31.96	32.24	32.10	104.32	97.54	100.93	1388.92	1546.85	1467.88
18.	F-4	38.47	38.09	38.28	89.59	89.18	89.39	721.65	649.357	685.50
19.	F-10	45.86	46.32	46.09	130.27	134.62	132.45	1052.89	1056.73	1054.81
20.	F-12	48.39	48.15	48.27	59.04	60.89	59.97	1245.72	1468.95	1357.33
21.	F-16	25.42	27.64	26.53	84.36	78.17	81.26	1694.28	1642.18	1668.23
22.	G-7	42.04	40.25	41.14	65.82	67.55	66.68	896.35	954.267	925.31
23.	G-19	29.48	29.62	29.55	126.49	122.63	124.56	1572.09	1496.41	1534.25
24.	G-28	39.36	38.59	38.98	95.28	97.56	96.42	1265.72	1298.46	1282.09
25.	G-30	44.65	42.15	43.40	68.65	72.12	70.39	967.48	1045.93	1006.70
26.	H-5	52.34	51.69	52.01	134.96	134.08	134.52	1051.29	1193.65	1122.47
27.	H-7	35.69	35.92	35.80	56.34	52.51	54.42	1294.75	1265.37	1280.06
28.	H-16	42.16	41.48	41.82	74.12	72.85	73.48	846.82	893.29	870.05
29.	H-17	38.48	38.72	38.60	108.46	112.69	110.58	1088.25	1157.37	1122.81
30.	H-32	32.52	30.58	31.55	122.09	122.32	122.20	1429.69	1265.42	1347.56
31.	H-49	40.36	40.15	40.25	93.85	90.47	92.16	792.64	947.86	870.25
32.	H-58	36.87	34.02	35.45	74.19	74.54	74.36	1184.71	1227.68	1206.20
33.	I-1	34.29	31.58	32.93	52.96	56.02	54.49	1267.49	1453.84	1360.67
34.	I-2	40.54	40.36	40.45	74.82	75.65	75.24	952.85	926.47	939.66
35.	I-3	32.82	31.59	32.20	59.08	62.14	60.61	1585.94	1628.32	1607.13
36.	I-4	36.09	34.24	35.17	96.49	96.72	96.61	1351.68	1341.96	1346.82
37.	Banaganapalle	31.36	30.78	31.07	109.52	112.36	110.94	1925.72	1958.49	1942.11
38.	Chinnarasam	38.65	32.02	35.34	53.95	52.48	53.22	1584.35	1392.87	1488.61
39.	Jalal	35.28	30.15	32.71	126.39	128.75	127.57	951.64	969.36	960.50
40.	Suvarnarekha	30.82	28.94	29.88	92.64	94.18	93.41	1143.89	1093.82	1118.85
	Mean			**36.32**			**91.38**			**1289.79**
	CD @ 5%			**1.09**			**2.65**			**36.31**
	SEM (±)			**0.39**			**0.94**			**12.88**

4. Discussion

Foods containing carotenoids, such as mango, in which β-carotene is the prevalent type of carotenes in the pulp, possess potent antioxidant properties. β-carotene contributes to the antioxidant capacity of mango by direct and indirect mechanisms. It can directly neutralize free radicals such as peroxyl (ROO·), hydroxyl (·OH), singlet oxygen ($^1O_2$), and superoxide (O_2^{-}) radicals, resulting in 5,8-carotene endoperoxides. This occurs *via* the donation of a hydrogen to produce a carotene radical, which at low oxygen concentrations can react with another ROO· leading to non-radical carotene peroxides. By binding to the antioxidant response element (ARE), the transcription factor Nrf2 activates indirect antioxidant mechanisms. This is necessary for the induction of phase II enzymes including glutathione *S*-transferases (GSTs), NAD(P)H: quinone oxidoreductase (NQO1) and thioredoxin (Tanaka *et al*., 2012).

This is supported by Jang *et al*. (2009) who stated that β-carotene (2 to 20 μM) is able to significantly reduce ROS production and activation of the NF-κB in AGS cells after *Helicobacter pylori* stimulation including down-regulated iNOS and COX-2 expression, and production of PGE2. PGE2 plays an important role in the process by activating PGE2 receptors, which increase β-catenin nuclear accumulation and transcriptional activity. The PGE2 also activates signal transduction pathways that favor growth of malignant tissue by enhancing cellular proliferation, promoting angiogenesis, inhibiting apoptosis, stimulating invasion or migration, and suppressing immune responses showed that consumption of mango juice during the 8 weeks following AOM injections to induce colorectal cancer, significantly reduced PGE2 levels compared with the control group, a result correlated with aberrant crypt foci (ACF), indicating mango consumption might contribute to control of carcinogenesis in colonic mucosa.

Mangoes are rich in antioxidants such polyphenols, phenolic compounds (phenolic acids and polyphenols) from mango may act directly as antioxidants from the effects of UV radiation, but can also interact with a wide group of cell molecules such as nuclear transcription factors (NR: nuclear receptors, Nrf2, RAR, RXR, NF-κB, MAPKs, PPARs) and MAPKs enzymes, able to modulate through the RARE, the antioxidant response element (ARE), the transcription of genes involved in cellular defense such as antioxidant enzymes (SOD, GSTs, NQO1), genes involved in the inflammatory system such as the cytokines TNFα and IL1β, the pro-inflammatory enzymes (COX-2, iNOS) for producing compounds such PGE-2 by COX-2, genes involved in apoptosis, glucose and fatty acid metabolism, and genes participating in cell survival and/or proliferation.

5. Conclusion

The study provides an extensive analysis of 36 genotypes and 4 checks of mango, emphasizing their considerable potential benefits for human and environmental health. Remarkably, these genotypes have promising antioxidant properties, making them viable candidates for meeting food requirements and positioning them as functional foods. Mangoes are rich in antioxidants such as phenols, carotenoids, and ascorbic acid. These antioxidants play crucial roles in mitigating oxidative stress, reducing the risk of chronic diseases, and promoting overall health. This study also emphasized the impact of genetic variation on the contents of these bioactive compounds. The findings of this research have important implications for the agriculture, nutrition, and food industries. The present investigation provides insight into the identification and selection of mango genotypes with high levels of specific bioactive compounds that can lead to the development of functional foods to meet the needs of consumers and health-conscious markets, ultimately contributing to food security and improved public health. Exploring the metabolic pathways and genetic factors that influence the content of bioactive compounds in mango can aid in the development of targeted breeding strategies to create mango varieties with optimized levels of antioxidants.

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Conflict of interest

The authors declare no conflicts of interest relevant to this article.

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