Agric Res J **59** (5) : 911-917, *October* 2022
DOI No. 10.5958/2395-146X.2022.00128.4

PHYSICO-CHEMICAL AND NUTRITIONAL CHANGES IN DIFFERENT MANGO HYBRIDS DURING FRUIT DEVELOPMENT

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ABSTRACT

Mango fruit is utilized from the immature to ripened stage depending upon its purpose of consumption. We planned to investigate physico-chemical and nutritional changes in six mango hybrids viz 'Pusa Lalima', 'Pusa Peetamber', 'Pusa Pratibha', 'Pusa Surya', 'Ambika' and 'Arunika' from 45 to 105 days after fruit set (DAFS). Results showed that fruit size, fruit weight, stone size & weight, and total soluble solids were maximum at final fruit development. In contrast, the titratable acidity presented a declining trend during the fruit development. The colour of fruit peel and pulp improved with fruit maturity. At various stages of fruit development, mango stone exhibited higher concentrations of nutrients than peel and pulp. At commercial maturity, the maximum fruit weight and size were observed by 'Pusa Surya' (279.2 g, 11.25 x 8.25 cm, respectively) and the maximum stone weight was also observed in 'Pusa Surya' (33.0 g). However, maximum total soluble solids (TSS) content was recorded in 'Ambika' (8.90 ^{0}Brix) fruits, and minimum titratable acid content was noted in 'Pusa Surya' (1.11 %).

Keywords: Fruit development, Mango hybrids, Nutrient concentration, Physico-chemical attributes

Mango is commercially grown in more than 80 countries of the world, and India is a leading producer in the world with an area of 2.25 million hectares and 21.82 million metric tonnes of production. In Punjab, mango occupies an area of 7.02 thousand hectares with a production of 1.18 lakh metric tonnes. Largely, the acceptability of mango fruit in the consumer market depends upon both the internal as well as external quality and the flavour being the most prominent. The metabolic changes involved during fruit development include an increase in ethylene production and respiration rate, fruit softening, and pigment changes that determines the optimum fruit harvest period. In general harvest stage of mango depend upon its utilization purpose; for instance immature stage of fruit is preferred for pickle, chutney and candy raw while for consumption as desert, squash, jam and jelly, fully mature or ripe fruits are chosen. The duration of fruit maturity period basically depends on the type of cultivar, environment and agronomic practice used. The quality and postharvest life of the fruit depends on the maturity stage at the time of harvesting and for the development of better quality the fruit should be harvested after attainment of harvestable maturity. Harvestable maturity can be predicted by examining the physical parameters like fruit weight, size, specific gravity, firmness and chemical parameters like TSS and acidity. Recently, IARI, New Delhi and CISH, Lucknow (India) has released regular bearing-coloured hybrids, namely 'Pusa Lalima', 'Pusa Peetamber', 'Pusa Pratibha', 'Pusa Surya', 'Ambika', 'Arunika' for domestic and global markets. Some of the earlier studies in these mango hybrids were conducted at full harvest maturity stage only. The findings of Lal *et al.* (2019) demonstrated the maximum fruit length in 'Pusa Lalima'; fruit weight in 'Pusa Surya' hybrid. Of course, these studies demonstrated that the optimum maturity of mango depends mainly upon cultivar type, ecological condition and stage of fruit harvest. Nevertheless, physico-chemical and nutrition changes in these mango hybrids, particularly at different stages of fruit maturity is still needed to be investigated for their suitability under Punjab conditions. Therefore, the present study was planned to evaluate mango hybrids for fruit quality attributes and nutritional composition during fruit development.

MATERIALS AND METHODS

Fruits of six hybrids viz. Pusa Lalima, Pusa Peetamber, Pusa Pratibha, Pusa Surya, Ambika, Arunika were picked from the College Orchard, Department of Fruit Science, Punjab Agricultural University, Ludhiana from 45 to 105 days after fruit set (DAFS) at 20 days interval during the year 2019. Healthy and uniform fruits were selected and after harvesting, fruits were cleaned with distilled water and wiped dry at room temperature. For the determination of physico-chemical properties and nutritional composition, the fruits were analysed in Post Graduate and Leaf Nutrition laboratories of the Department of Fruit Science. At each sampling, ten healthy and uniform fruits per replication were used for the estimation of physico-chemical attributes. For nutrient estimation, different fruit parts such as peel,

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Date of receipt: 01.06.2022, Date of acceptance: 31.10.2022

pulp and stone were separated manually and placed in a hot air oven (65 ^{0}C) for moisture removal. Fruit and stone weight were recorded using electronic weighing balance and expressed in grams (g). Fruit and stone size in terms of length and breadth was recorded with Vernier Caliper and expressed in centimetres (cm). Fruit peel and pulp colour coordinates as *L*, a* and b** colour were measured from two opposite sides of the fruit by using Colour Flex 45^o/0^o spectrophotometer (Hunter Lab, Hunter Associates Laboratory Inc., Reston, Virginia, USA). TSS content was determined using a digital hand refractometer (Atago, Japan) and expressed in ^{0}Brix. The titratable acidity of fruit was determined by titrating 2.0 ml of juice against 0.1 N NaOH solution using phenolphthalein indicator and was expressed in percentage (%). For the purpose of estimation of nutrient content in the peel, pulp and stone of mango hybrids, tissues were oven dried and ground into powder. For nitrogen estimation, 0.5 g of the sample was digested with concentrated H_2SO_4 with digestion mixture in Kel Plus Nitrogen estimation system (Pelican Equipments, India) and titrated by boric acid (Kjeldahl method). For other nutrient estimation, 0.5 g sample digested with di-acid mixture (HNO_3:$HClO_4$ in 4:1). Phosphorus was estimated by the Vanado-Molybdo phosphate yellow colour method (Chapman and Pratt, 1961). Potassium was estimated by the Flame Photometer method (Jackson, 1973). Other nutrients like Ca, Fe, Zn, Mg, Cu and Mn were estimated by Atomic Absorption Spectrometer (AAnalyst 200, Perkin Elmer, USA) described by Bradfield and Spencer (1965). The experiment was carried out in Randomized Block Design with three replications per each treatment. Data were analysed for one-way analysis of variance (Proc GLM) using the statistical package SAS 9.3 (The SAS system for Windows, Version 9.3, SAS Institute, Cary, NC). Variations among the means were assessed by the least significant square test at $p \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

Physico-chemical changes during fruit development

Fruit weight and size of various mango hybrids increased with the progression of fruit maturity period from 45 to 105 DAFS (Table 1) and it presented a single sigmoid growth curve. The maximum fruit size (11.25 cm length, 8.25 cm breadth) and weight (279.2 g) was observed in 'Pusa Surya' at 105 DAFS, whereas minimum fruit length (6.96 cm) and weight (49.3 g) was recorded in 'Arunika' fruits at 45 DAFS. The increase in weight is due to an increase in fruit and stone size. Bora *et al.* (2017) showed that 'Pusa Surya' had maximum fruit weight, while 'Ambika' recorded maximum fruit and stone length at full maturity. Pandey *et al.* (2014) observed 234.57 g weight in the case of 'Pusa Surya' fruits. Increase in fruit size during fruit development could be due to the increased uptake of more nutrients and build-up of sufficient photosynthates leading to the increase in size of fruits.

Table 1. Changes in fruit weight, fruit size, stone weight and stone size in mango hybrids during fruit development

Hybrid	Fruit											
	45 DAFS			65 DAFS			85 DAFS			105 DAFS		
	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)	Weight (gm)	Length (cm)	Breadth (cm)
Ambika	111.6	7.20	4.40	170.2	8.55	5.20	222.0	9.21	5.64	261.4	9.43	6.04
Arunika	49.3	6.96	4.42	91.6	7.70	4.87	160.8	8.23	5.31	192.5	8.63	5.69
PusaPeetamber	77.0	8.06	4.25	100.9	8.81	4.62	165.7	9.31	4.90	218.9	9.55	5.16
Pusa Lalima	88.1	8.40	4.05	131.3	9.41	4.68	190.1	10.36	5.18	225.7	10.78	5.57
Pusa Pratibha	71.0	8.57	4.43	100.4	9.86	4.66	174.3	10.25	5.11	222.5	10.50	5.45
Pusa Surya	95.3	8.75	6.90	181.6	9.92	7.41	245.5	10.88	7.95	279.2	11.25	8.25
LSD (0.05)	7.5	0.75	0.26	6.9	0.33	0.48	8.0	0.27	0.59	10.6	0.38	0.36
						Stone						
Ambika	11.4	4.02	1.70	17.5	5.61	2.45	24.5	6.68	2.84	26.0	7.58	3.16
Arunika	6.2	2.70	1.83	10.1	3.70	2.24	17.2	4.21	2.36	20.7	4.43	2.46
PusaPeetamber	4.7	4.29	1.80	6.4	5.77	2.46	10.3	6.98	2.73	11.9	7.57	2.95
Pusa Lalima	12.3	4.13	2.16	18.1	5.94	2.46	22.9	7.32	2.75	25.1	8.22	2.94
Pusa Pratibha	9.0	3.36	2.11	12.1	4.99	2.70	17.5	6.48	2.92	20.1	7.45	3.04
Pusa Surya	19.6	4.50	1.87	24.5	5.44	2.83	31.0	6.22	3.57	33.0	6.92	3.86
LSD (0.05)	1.5	0.48	0.25	1.4	0.53	0.29	3.7	0.48	0.39	2.2	0.42	0.52

During the fruit development, the stone weight increased linearly till the final harvest stage in all mango hybrids (Table 1). Stone weight and size showed greater growth at the initial stages (45 to 85 DAFS) than at later stages (85 to 105 DAFS). Minimum stone size (2.70 cm length) in 'Arunika' and 1.70 cm breadth was recorded in 'Ambika' fruits and weight (4.7 g) in 'Pusa Peetamber' at 45 DAFS. Likewise, the maximum stone breadth (3.86 cm) and weight (33.0 g) was recorded in 'Pusa Surya' and stone length (8.22 cm) in 'Pusa Lalima' fruits at 105 DAFS. Anila and Radha (2003) recorded stone weight in range of 22.55 to 47.47 g in various mango varieties.

As the fruit approaches towards maturity, fruit peel and pulp colour coordinates of fruit exhibited an increment, except the luminosity coordinate (*L**) of the pulp which showed a decreasing trend. The colour coordinates of fruit pulp were comparatively higher than peel (Table 2). *L** coordinate was maximum (42.56) in 'Arunika' peel at 105 DAFS and in 'Ambika' pulp at 45 DAFS whereas minimum in 'Pusa Surya' pulp at 105 DAFS and 'Pusa Pratibha' peel at 45 DAFS. At the end of fruit development period the minimum pulp *a** coordinate was found in 'Pusa Lalima' and maximum in 'Pusa Surya'. Similarly, at harvest, maximum a* value (1.99) of peel was observed in 'Pusa Pratibha' while minimum a* value (-8.54) was recorded in 'Pusa Peetamber'. The value of *b** coordinate was found maximum in 'Pusa Surya' (both in peel and pulp) at 105 DAFS and minimum in 'Pusa Pratibha' (pulp) at 45 DAFS and in 'Pusa Peetamber' (peel). The declining trend of lightness and enhancing pattern of *a** and *b** value has been observed in the inner portion of mango when the colour of fruit pulp was transformed from white to yellow with maturity (Nambi *et al.*, 2015).

The total soluble solids (TSS) content of fruit is an important quality parameter of mango fruit. A significant increment in TSS content was seen with fruit maturity with gradual decrease in the acidity of juice (Table 3). The variations in TSS are associated with changes in carbohydrate content during storage and hydrolysis of complex starch into simple sugar molecules by enzymatic activities (Zhong *et al.*, 2006). Decrease in fruit acidity during ripening is attributed due to the conversion of organic acids into sugars (Velez-Rivera *et al.*, 2013). Maximum TSS content (8.90 ^{0}Brix) was noted in juice of 'Ambika' fruits up to 105 DAFS, whereas minimum TSS (6.69 ^{0}Brix) in 'Pusa Surya' fruits at 45 DAFS. Maximum (2.46 %) juice acid content was recorded in 'Ambika' at 45 DAFS whereas minimum (1.11%) in 'Pusa Surya' fruits up to 105 DAFS. Rooban *et al.*, (14) also revealed lower TSS and higher acidity during the immature stage and higher TSS and lower acidic content in mango fruits at the final maturity stage.

Nutritional changes during fruit development

Different macronutrient contents such as nitrogen, phosphorus and potassium content of fruits showed variations in fruit peel, pulp and stone from 45 to 105 DAFS. But no definitive pattern was observed in

Table 2. Changes in fruit colour coordinates in mango hybrids during fruit development

Hybrid	Fruit pulp											
	45 DAFS			65 DAFS			85 DAFS			105 DAFS		
	L	a	b	L	a	B	L	a	b	L	a	b
Ambika	88.45	-4.36	29.64	87.75	-3.89	30.87	84.02	-3.68	32.03	81.26	-3.45	34.54
Arunika	88.28	-3.64	36.48	87.28	-3.36	37.36	86.97	-2.82	39.28	86.71	-2.76	41.99
PusaPeetamber	86.04	-4.16	39.99	85.60	-4.10	42.98	83.54	-3.72	46.43	82.28	-3.51	47.52
Pusa Lalima	87.58	-4.84	27.36	85.44	-4.67	28.65	84.96	-4.63	29.27	84.73	-4.53	29.83
Pusa Pratibha	85.42	-4.52	18.73	83.13	-4.05	21.02	82.51	-3.83	21.45	82.29	-3.57	22.89
Pusa Surya	83.83	-3.18	41.30	81.70	-2.92	45.43	79.41	-2.30	49.54	78.46	-2.10	51.09
LSD (0.05)	0.08	0.13	0.19	0.20	0.14	0.54	0.71	0.09	0.10	0.09	0.15	0.28
						Fruit peel						
Ambika	26.00	-4.87	12.71	28.63	-4.36	12.77	31.79	-3.90	13.31	35.81	-3.28	13.61
Arunika	33.05	-2.33	13.82	36.95	-2.02	16.51	38.47	-1.73	18.76	42.56	-1.48	21.66
PusaPeetamber	33.57	-9.40	12.19	34.26	-8.98	15.63	36.25	-8.72	18.34	38.87	-8.54	20.45
Pusa Lalima	30.96	-2.63	14.39	32.70	-2.58	16.66	35.18	-2.40	17.10	38.85	-2.03	18.26
Pusa Pratibha	24.82	0.39	19.12	27.60	0.65	19.46	30.04	1.26	19.88	34.39	1.99	21.22
Pusa Surya	30.52	-6.45	21.36	32.18	-5.90	23.94	36.98	-5.74	24.86	39.05	-5.34	25.41
LSD (0.05)	1.74	0.32	0.12	2.56	0.29	0.27	2.70	0.23	0.32	3.69	0.47	0.26

Table 3. Changes in biochemical properties in mango hybrids during fruit development

Hybrid	45 DAFS		65 DAFS		85 DAFS		105 DAFS	
	TSS (°Brix)	Acidity (%)	TSS (°Brix)	Acidity (%)	TSS (°Brix)	Acidity (%)	TSS (°Brix)	Acidity (%)
Ambika	7.17	2.46	7.94	2.17	8.43	1.77	8.90	1.28
Arunika	7.46	2.24	8.00	1.92	8.50	1.54	8.80	1.12
PusaPeetamber	7.18	2.34	7.97	2.08	8.46	1.69	8.80	1.28
Pusa Lalima	7.53	2.10	8.09	1.98	8.43	1.60	8.70	1.13
Pusa Pratibha	6.74	2.42	7.42	2.20	8.08	1.95	8.50	1.44
Pusa Surya	6.69	1.96	7.20	1.89	7.80	1.55	8.20	1.11
LSD (0.05)	0.42	0.33	0.39	0.26	0.32	0.18	0.35	0.11

macro-nutrients concentration in different fruit parts i.e., peel, pulp and stone during fruit development period. However, a higher concentration of macro-nutrients was observed in stone followed by peel and pulp except for P in 'Ambika', 'Arunika' and 'Pusa Peetamber' at 105 DAFS (Table 4). Njiru *et al*., (2014) also found that mango peel contains significantly higher levels of nutrient than pulp in order of: Ca > K > mg > Na > Fe > Mn > Zn > Cu, which has also been justified in the present study. Maximum N content was recorded in fruit peel (0.97%) in 'Arunika' and 'Pusa Pratibha' at 85 DAFS and stone (1.08%) of 'Pusa Peetamber' fruits at 105 DAFS and pulp (0.91%) of 'Arunika' at 85 DAFS whereas minimum in peel (0.57%) of 'Arunika' at 105 DAFS and pulp (0.60 %) of 'Pusa Lalima' at 45 DAFS and stone (0.75%) of 'Arunika' fruits. Maximum P content was recorded in peel (0.376%) in 'Ambika' fruits at 45 DAFS and pulp (0.413%) of 'Pusa Pratibha' at 85 DAFS and stone (0.471%) of 'Ambika' at 45 DAFS whereas, minimum in peel (0.212%) in 'Pusa Peetamber' at 85 DAFS, in pulp (191%) of 'Ambika' at 85 DAFS and stone (0.246%) in 'Pusa Lalima' at 85 DAFS.

Maximum K content (%) was recorded in peel (0.93%) in 'Pusa Pratibha' and pulp (1.09%) of 'Pusa Peetamber' and 'Pusa Lalima' and also in stone (1.03%) of 'Pusa Lalima' at 45 DAFS and minimum in peel (0.59%) of 'Arunika' at 45 DAFS and pulp (0.39%) and stone (0.35%) of 'Ambika'at 85 DAFS. Maximum Ca content was registered in the peel (2.76%) at 105 DAFS and pulp (2.42 %) at 45 DAFS of 'Ambika' and stone of 'Pusa Peetamber' (2.34%) at 45 DAFS. However, minimum Ca was recorded in peel (0.84%) in 'Pusa Peetamber' at 105 DAFS and pulp (0.31%) of 'Pusa Surya' at 105 DAFS and stone (0.66%) of 'Pusa Lalima' fruits at 45 DAFS. Maximum Mg content was registered in the peel (0.92%) in 'Ambika' fruits at 85 DAFS and pulp (0.54%) and stone (0.47%) of 'Pusa Pratibha' at 45 DAFS. However, minimum Mg was recorded in peel (0.14%) of 'Pusa Peetamber' at 45 DAFS and pulp (0.09%) in 'Pusa Peetamber'at 105 DAFS and stone (0.15%) of 'Arunika' fruits at 105 DAFS.

Micronutrient content plays an important role in fruit growth and development. Micronutrient content in fruit peel, pulp and stone parts of studied mango hybrids did not follow a specific pattern during the fruit development period. However, higher concentration of micronutrients was observed in stone, followed by peel and pulp (Table 5). Lebaka *et al.,* (2021) also justified the present study by demonstrating the higher concentration of micronutrients in mango peel (40.6, 1.74, 10.4 mg/100g for Fe, Zn and Cu, respectively) than pulp (0.16, 0.09, 0.04 to 0.32 mg/100g for Fe, Zn and Cu, respectively) at the final stage of harvesting.

Maximum Zn content was recorded in peel (29.20 ppm) of 'Pusa Lalima' at 45 DAFS and stone (23.60 ppm) of 'Ambika' at 105 DAFS and to the tune of 27.80 ppm in the pulp of 'Pusa Peetamber' at 105 DAFS whereas, minimum of 5.20 ppm in the peel of 'Arunika' and 6.0 ppm in the pulp of 'Pusa Lalima' at 105 DAFS, while 10.0 ppm in stone of 'Pusa Surya' at 85 DAFS.

In peel, the maximum Mn (52.0 ppm) and Cu (22.4 ppm) content was observed in 'Pusa Lalima' and 'Pusa Pratibha' at 105 DAFS. Fe content was noted as maximum (198 ppm) in 'Pusa Pratibha' at 45 DAFS, whereas in stone, maximum Fe content was reported in 'Pusa Surya' at 85 DAFS, and Cu content was highest in 'Arunika' at 85 DAFS; while 'Ambika' recorded highest Mn content at 105 DAFS. In pulp, the maximum Mn content (24.2 ppm), Fe content (165 ppm) and Cu content (28.0 ppm) was observed in 'Pusa Surya', 'Pusa Pratibha' and 'Ambika' fruits, respectively, at 45 DAFS. Duran-Zuazo *et al*., (2005) while working on mango fruit nutrients, concluded that the concentration of macronutrients decreased during the growth and development of fruit but micronutrient concentration increased with maturity. Kour *et al*., (2018) while working on 'Dashehari' mango concluded that the concentration of N, P and K decreased and the concentration of Ca and Mg increased in the pulp during fruit development, but in micronutrient concentration, no definite pattern

Table 4. Changes in macro-nutrient content in different parts of mango hybrids during fruit development

Hybrid	N (%)											
	45 DAFS			65 DAFS			85 DAFS			105 DAFS		
	Peel	Pulp	Stone	Peel	Pulp	Stone	Peel	Pulp	Stone	Peel	Pulp	Stone
Ambika	0.68	0.66	0.67	0.81	0.78	0.84	0.94	0.89	1.01	0.75	0.76	0.96
Arunika	0.67	0.76	0.60	0.82	0.84	0.74	0.97	0.91	0.87	0.57	0.68	0.80
PusaPeetamber	0.74	0.62	0.67	0.83	0.76	0.85	0.91	0.90	1.03	0.70	0.61	1.08
Pusa Lalima	0.62	0.60	0.72	0.66	0.66	0.80	0.71	0.73	0.87	0.80	0.77	0.76
Pusa Pratibha	0.68	0.64	0.69	0.82	0.75	0.87	0.97	0.86	1.06	0.70	0.67	1.00
Pusa Surya	0.64	0.68	0.67	0.74	0.73	0.76	0.84	0.78	0.85	0.68	0.71	0.85
LSD (0.05)	0.01	0.04	0.04	0.01	0.01	0.01	0.01	NS	0.02	0.03	0.05	0.02
						P (%)						
Ambika	0.376	0.384	0.471	0.327	0.288	0.359	0.279	0.191	0.246	0.256	0.256	0.468
Arunika	0.313	0.350	0.346	0.271	0.293	0.380	0.229	0.236	0.413	0.228	0.326	0.396
PusaPeetamber	0.254	0.388	0.426	0.233	0.317	0.434	0.212	0.246	0.441	0.245	0.277	0.346
PusaLalima	0.338	0.363	0.246	0.277	0.306	0.324	0.216	0.249	0.401	0.224	0.216	0.429
Pusa Pratibha	0.350	0.369	0.443	0.290	0.391	0.359	0.229	0.413	0.274	0.362	0.254	0.288
Pusa Surya	0.309	0.342	0.350	0.263	0.302	0.321	0.216	0.262	0.291	0.256	0.256	0.266
LSD (0.05)	0.025	0.027	0.023	0.040	0.023	0.015	0.030	0.018	0.024	0.014	0.015	0.012
						K (%)						
Ambika	0.89	0.83	0.79	0.76	0.61	0.57	0.63	0.39	0.35	0.73	0.63	0.53
Arunika	0.59	0.75	0.59	0.61	0.89	0.81	0.63	1.03	1.03	0.69	0.73	0.33
PusaPeetamber	0.63	1.09	0.65	0.68	0.81	0.69	0.73	0.53	0.73	0.63	0.59	0.63
Pusa Lalima	0.73	1.09	1.03	0.76	0.77	0.91	0.79	0.45	0.79	0.83	0.53	0.29
Pusa Pratibha	0.93	0.99	0.63	0.81	0.91	0.61	0.69	0.83	0.59	0.79	0.83	0.43
Pusa Surya	0.79	0.83	0.83	0.74	0.73	0.71	0.69	0.63	0.59	0.73	0.89	0.65
LSD (0.05)	0.04	0.04	0.20	0.04	0.04	0.15	0.04	0.03	0.04	0.04	0.20	NS
						Ca (%)						
Ambika	2.12	2.42	1.55	2.38	2.21	1.51	2.64	2.00	1.48	2.76	1.65	1.65
Arunika	1.59	1.54	1.88	1.64	1.56	1.64	1.68	1.58	1.41	1.37	1.96	1.67
PusaPeetamber	1.17	0.35	1.52	1.01	0.43	1.56	0.86	0.50	1.60	0.84	0.32	1.33
Pusa Lalima	1.37	1.32	0.66	1.32	1.00	0.81	1.28	0.67	0.97	1.23	0.44	0.84
Pusa Pratibha	2.30	1.68	2.34	2.14	1.36	1.91	1.98	1.04	1.48	1.42	1.41	1.37
Pusa Surya	1.45	0.72	1.77	1.15	0.68	1.48	0.85	0.64	1.20	1.24	0.31	1.22
LSD (0.05)	0.16	0.09	0.08	0.12	0.15	0.05	0.10	0.12	0.09	0.11	0.16	0.09
						Mg (%)						
Ambika	0.50	0.46	0.36	0.71	0.36	0.31	0.92	0.25	0.27	0.80	0.43	0.26
Arunika	0.30	0.29	0.40	0.36	0.24	0.28	0.42	0.18	0.15	0.14	0.10	0.34
PusaPeetamber	0.14	0.22	0.32	0.18	0.17	0.28	0.22	0.12	0.24	0.18	0.09	0.25
Pusa Lalima	0.29	0.37	0.26	0.30	0.27	0.29	0.32	0.17	0.32	0.25	0.14	0.17
Pusa Pratibha	0.19	0.54	0.47	0.29	0.42	0.33	0.39	0.30	0.20	0.29	0.30	0.19
Pusa Surya	0.31	0.16	0.27	0.27	0.18	0.27	0.22	0.19	0.26	0.26	0.17	0.25
LSD (0.05)	0.08	0.10	0.14	0.07	0.06	NS	0.21	0.07	NS	0.12	0.04	0.09

Table 5. Changes in micro-nutrient content in different parts of mango hybrids during fruit development

Hybrid	Zn (ppm)											
	45 DAFS			65 DAFS			85 DAFS			105 DAFS		
	Peel	Pulp	Stone	Peel	Pulp	Stone	Peel	Pulp	Stone	Peel	Pulp	Stone
Ambika	18.6	21.2	22.0	19.7	20.9	20.2	20.8	20.6	18.4	15.0	13.4	23.6
Arunika	18.8	16.8	16.8	13.5	14.7	18.2	8.2	12.6	19.6	5.2	14.2	14.6
PusaPeetamber	14.0	24.2	17.4	13.3	25.1	16.2	12.6	26.0	15.0	12.0	27.8	13.4
Pusa Lalima	29.2	21.6	18.6	21.2	15.5	17.9	13.2	9.4	17.2	10.6	6.0	19.2
Pusa Pratibha	12.4	19.4	14.4	13.0	21.7	15.9	13.6	24.0	17.4	9.0	21.2	21.0
Pusa Surya	13.0	14.8	16.4	12.0	15.7	13.2	11.0	16.6	10.0	14.0	15.6	17.2
LSD (0.05)	0.4	0.3	0.3	NS	1.2	0.6	0.4	0.3	0.4	0.4	0.5	0.4
	Mn (ppm)											
Ambika	15.2	19.9	53.8	15.6	16.3	49.1	16.0	12.6	44.4	15.0	14.8	52.6
Arunika	11.2	20.8	44.6	12.7	22.2	45.7	14.2	23.6	46.8	16.6	23.2	43.8
PusaPeetamber	36.2	12.0	18.6	32.1	14.6	16.6	28.0	17.2	14.6	26.8	18.6	15.4
Pusa Lalima	47.6	14.4	34.0	49.8	16.4	35.5	52.0	18.4	37.1	51.4	16.4	43.4
Pusa Pratibha	22.6	22.0	12.4	23.5	17.4	14.9	24.5	12.8	17.4	25.4	14.4	20.0
Pusa Surya	27.6	24.2	16.2	26.5	23.2	22.5	25.4	22.2	28.8	26.4	17.2	34.4
LSD (0.05)	0.3	0.4	0.5	0.3	0.2	0.3	0.5	0.3	3.3	0.3	0.3	0.3
	Fe (ppm)											
Ambika	159.7	122.8	124.0	156.3	134.5	134.6	152.8	124.8	145.2	159.2	125.8	168.0
Arunika	191.2	136.2	113.0	163.1	137.4	129.3	135.0	138.6	145.6	134.0	126.0	158.4
PusaPeetamber	158.0	156.0	160.0	155.5	152.4	143.9	153.0	148.8	127.8	156.0	138.0	124.0
Pusa Lalima	174.2	130.0	157.0	180.1	121.0	154.5	186.0	112.0	152.0	185.6	113.4	146.0
Pusa Pratibha	198.0	165.0	122.4	174.0	146.5	145.7	150.0	128.0	169.0	150.0	154.0	168.0
Pusa Surya	156.6	125.8	183.0	155.6	118.4	184.5	154.6	111.0	186.0	153.2	112.0	182.0
LSD (0.05)	0.3	0.2	0.6	0.5	0.4	1.1	1.0	0.2	1.3	0.3	0.3	0.8
	Cu (ppm)											
Ambika	10.4	28.0	19.4	13.7	23.4	18.5	17.0	18.8	17.6	12.4	12.2	17.6
Arunika	14.6	8.2	12.9	9.9	6.7	18.1	5.2	5.2	23.2	5.6	7.6	13.2
PusaPeetamber	10.6	11.0	11.0	8.4	10.3	11.7	6.2	9.6	12.4	7.0	13.2	13.8
Pusa Lalima	16.2	10.0	10.0	16.1	8.9	14.8	16.0	7.8	19.6	17.8	7.8	15.0
Pusa Pratibha	12.7	14.8	18.8	17.6	18.3	17.5	22.4	21.8	16.2	12.4	16.2	20.8
Pusa Surya	7.4	12.8	13.4	7.2	10.5	13.2	7.0	8.2	13.0	7.4	7.0	13.8
LSD (0.05)	0.7	0.4	0.5	0.9	0.3	0.4	1.0	0.4	0.5	0.9	0.4	2.6

was observed in the pulp of 'Dashehari' mango.

The present study showed that the fruit size, TSS, fruit peel and pulp colour coordinates, except the luminosity coordinate of pulp had increased during fruit growth, whereas acidity and luminosity coordinate of pulp decreased. The fruit nutrient showed no definite pattern during development; however higher concentration of nutrients was noted in stone, followed by peel and pulp in fruit. It is summarized that fruit growth and maturation in mango hybrid 'Pusa Surya' fruits were better in comparison to other hybrids in terms of fruit size, weight, TSS content and juice acidity.

Authors' contribution

Conceptualization of research (HG, MS); Designing of the experiments (MS,NS); Contribution of experimental materials (HG, NS); Execution of field/lab experiments and data collection (HG, MS); Analysis of data and interpretation (HG, PPSG); Preparation of the manuscript (HG, MS, PPSG).

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