

Physico-chemical Characterization of Unexploited Mango Diversity in Sub-montane Zone of Northern India

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In Punjab province of India, area under mango (*Mangifera indica* L.) fruit plantation in the state has declined drastically due to deforestation, population pressure, shifting to high remunerative cropping systems, reoccurrence of cold waves, developmental works, higher incidence of pests and diseases, etc. Hence, a survey was conducted for documentation about the extent of diversity found in the native landraces/strains of mango. Twenty eight elite strains enjoying local patronage were evaluated for table and sucking purposes, preparation of pickle/canning/beverages/amb leather on the basis of physical appearance and chemical attributes. Physico-chemical analysis of fruit samples revealed that variability found in indigenous mango population in various qualitative and quantitative attributes not only contributes to biological diversity, nutritional security and livelihood but can also be used for crop improvement. The present study highlights that it is the need and demand of Punjabi folklore to conserve and protect such biologically rich areas for the benefit of posterity.

Key Words: Biodiversity, *Mangifera indica*, Economic valuation

Introduction

India is traditionally world's largest producer of mango (*Mangifera indica* L.) contributing nearly 49.1% of the total global mango production from an area of 2.31million ha with an annual production of 15.0 mt. During 2009-10, almost \$ 9.8 million foreign exchange was earned from the export of fresh mango fruits and their value added products, i.e. mango pulp, pickles, jam, squashes, chutney, slice etc. Mango fruit is a rich source of vitamin A and C, potassium, β -carotene, amino acids, minerals and antioxidants; and also contain an enzyme showing stomach soothing properties. Mango originated in Indo-Malayan region stretching from India to the Philippines and Papua New Guinea. It belongs to family Anacardiaceae and comprises 69 species of genus *Mangifera*, which are distributed throughout the world (Kostermans and Bompard, 1993). It is domesticated in the Indian sub-continent dates back to at least 4000 years; however, importance to its plantation was given during the dynasty of Mughals.

Mango is highly cross-pollinated and heterozygous fruit crop, thus exhibits wide genetic variability in seedling population. Majority of cultivated mango varieties were developed through selection on the basis of fruit shape, colour, size, flavour, aroma, taste, time of maturity, juice

content, TSS/acid blend, etc. Presently, India harbours more than 1000 mango varieties/landraces in different diversity regions and represents the biggest mango germplasm in the world. In Punjab province of India, nearly 80% of total mango growing areas are confined to sub-montane zone. In this region, old mango plantation predominantly from seedling origin are established naturally or propagated through selected stones from meritorious indigenous mango plants on the basis of fruit quality characteristics by local fruit lover during 19th and early 20th century. These are at present mostly growing along a strip of roads, riverbanks, undulated terrain in mountainous tracts, government revenue lands, mango groves etc., exhibit a wide range of variability in desirable horticultural traits like fruit shape, size, juice consistency, bearing regularity, fruit yield, tolerance/resistance to various biotic and abiotic stresses etc. (Navprem *et al.*, 2011).

Besides, enhancing biodiversity in natural habitat and providing nutrition security to local population, these seedling mangoes provide a wealth of variability for carrying out selections of desirable strains and ensure continuous supply of novel genetic material for future crop improvement (Singh and Jawanda, 1963). Likewise, Ravishankar *et al.* (2000) reported that knowledge of

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a diverse genetic gene pool is essential in designing future breeding strategies for sustainability in mango production. It is therefore, germplasm act as basis of variation for new assortment and necessary to conserve these precious genetic resources through collection of local indigenous germplasm. It is well documented that mango cultivars/strains/landraces/clones are developed from open-pollinated seedling progenies viz. 'Neldawn', 'Neldica', 'Heidi' and 'Ceriese' in South Africa (Marais, 1992); 'Manipur-I' and II mango clones in North-eastern region of India (Chadha and Yadav, 1996); 'Paiyur-1' from 'Neelum' mango cultivar (Yadav, 1997); 'Dashehari-51' from 'Dashehari' mango cultivar (Negi, 1997); 'Rumang' a chance seedling of 'Xiangmang' mango in China (Luo and He, 1996); 'Gangian Sindhuri' (Sharma *et al.*, 2006) and 'Ataulfo' from 'Manila' mango in Mexico (Galan Sauco, 2011). Rajwana *et al.* (2011) reported that most of the mango cultivars grown in Pakistan have been selected from the seedling population of 'Chaunsa' or hybrids developed by using it as one of the parents. Hence, the present survey was carried out to investigate the nature and assessment of genetic variability in mango seedling progenies for physico-chemical attributes.

Material and Methods

A survey of indigenous mango seedlings was carried out jointly by Punjab Agricultural University and Punjab Biodiversity Board, Chandigarh (India) for the evaluation of elite germplasm and to conserve in situ, in their wild habitats, where these can continue to adopt and grow along with their natural surroundings. Mango samples from more than twenty eight apparently phenotypically different mango varieties/landraces, locally popular for their high performance and good quality fruit as per the information provided by Department of Forests and Wildlife (Hoshiarpur), Department of Horticulture (Punjab) and feed back from local villagers etc., were selected before harvesting period. Fruits from marked trees were collected randomly at the time of their respective harvesting period and analysed for various physico-chemical traits in the laboratory. Average fruit and stone size, peel weight, stone weight, pulp weight, fruit weight, pulp/stone ratio, fruit colour, flavour and time of maturity were determined using standard methods. The juice was extracted from the pulp by straining through a muslin cloth and total soluble solids were noted with Bausch and Lomb hand refractometer and expressed in terms of degree brix and values were corrected at 20°C. Juice acidity was estimated by titrating 2 ml juice

against 0.1 N NaOH using phenolphthalein as indicator (AOAC, 1980). Total sugars, reducing sugars and non-reducing sugars were determined by volumetric method. The data was analysed as per the method by Gomez and Gomez (1984).

Results and Discussion

The data pertaining to physico-chemical attributes of elite mango strains along with common vernacular name indicating a great diversity (Table 1-3). Some interesting mango strains observed in the area are locally known as *Anda Dusehree* (flavour & taste resembled to a popular Indian table purpose mango variety 'Dashehari', but fruit shape was looked like egg), *Laddu Amb*, *Gola Ghassipur* and *Ber Amb* on the basis of fruit shape. In Punjabi folklore, native mango strains are called as '*Chhalli*' on account of their oblong shape and large fruit size (resembling a small sized corn cob). Attractive yellow fruit colour with red blush on the shoulders was observed in seven mango strains (*Anami Chhalli*, *Choe Sindhuri*, *Ghassipur di Chhalli*, *Laddu Amb*, *Mahantan di Laltain*, *Sindhuri Chusa*). Fruit colour ranged from yellowish to light yellow, deep chrome, greenish, spinach green and dark green in rest of selected mango strains. Fully coloured fruits are locally preferred and called as *Arru Amb* and *Pencil Amb*. These are preferred for sucking type of mangoes mostly due to thin and abundant juice content; soft flesh, coarse fibres and sell at higher price in the area.

Maximum fruit weight (380.4 g) and fruit length (12.52 cm) was found in strain *Jogiya Chhalli* collected from Government Orchard, Bhunga and percentage contribution of pulp, peel and stone in the fruit was 70.3, 16.0 and 13.7, respectively. Minimum average fruit weight of 60.1 g was recorded in *Ber amb* (which appeared like a ripe fruit of *Zizyphus* species). The highest fruit pulp weight (267.5 g) was also recorded in *Jogiya Chhalli*, followed by *Achari Gola* (186.1 g), *Thudi Amb* (155.5 g), *Gola Desi* (153.2 g) and the lowest fruit pulp weight was recorded in *Ber Amb* (18.3 g). The average stone weight in different strains varied from 19.2 g to 64.5 g; being maximum in *Achari Gola* and minimum in *Arru Amb* (tastes like a *Prunus persica*). Peel weight in strains- *Mahantan di Chhalli*, *Thudi Amb*, *Banta Amb No. 1* and *Jogiya Chhalli* ranged from 46.6 g to 60.8 g; however, it was the lowest (12.5 g) in *Kala Amb*. Higher pulp/stone ratio is a favourable physical character in mango and it varied from 0.94 in *Ber Amb* to 5.13 in

Table 1. Phenotypic characters of sucking mango varieties in district Hoshiarpur

Strains	Sample collection site	Fruit shape	Fruit colour	Time of fruit maturity	Pulp colour	Fruit taste	Flavour	Presence of fibres
Achari Gola	Inami Bagh	ovate oblong	Yellow	2 nd week of July	Yellow	sweet	Pleasant	Abundant short
Anami Amb	Inami Bagh	ovate	Yellow with red blush	4 th week of July	Yellow	very sweet	Pleasant	Absent
Anami Chhalli	Inami Bagh	oblong	Yellowish green	3 rd week of July	Creamish yellow	very sweet	Pleasant	Sparse short
Anda Dushehree	Inami Bagh,	ovate	Yellowish green	1 st week of July	Creamish	Sweet	Pleasant	Absent
Arru amb	Inami Bagh	round	Sindhuri yellow	2 nd week of July	Orange	Sweet	Pleasant	Scanty
Banita Amb No. 1	Village Darapur	ovate oblong	Yellowish green	2 nd week of July	Creamish	Sour	Pleasant	Abundant long
Banita Amb No. 2	Village Darapur	ovate oblong	Yellowish green	2 nd week of July	Yellow	Sour	Pleasant	Abundant long
Banita Amb No. 3	Village Darapur	round	Spinach green	3 rd week of July	Yellow	Sour	sonfia	Abundant long
Ber Amb	Inami Bagh	round	Deep chrome	1 st week of July	Yellow	very sweet	Sonfia	Scanty short
Bhagva Chhalli	Inami Bagh	ovate oblong	Yellowish green	1 st week of July	light yellow	very sweet	Pleasant	Scanty short
Chhalli No. 18	Village Daifrar	oblong	Yellowish	2 nd week of July	Yellow	superb	Pleasant	Abundant long
Charan Achari	Ghassipur Orchard	ovate oblong	Greenish	2 nd week of July	Orange	Sour	Sonfia	Scanty
Choe Sindhuri	Ghassipur Orchard	ovate	Yellowish with red blush on shoulders	1 st week of August	Light yellow	Sour	Pleasant	Long all over
Ghassipur Amb	Ghassipur Orchard	ovate	Yellowish red tinge	2 nd week of July	Yellow	very sweet	Pleasant	Scanty
Gola Desi	Inami Bagh	round	Light yellow	2 nd week of July	Yellow	Sweet	Pleasant	Abundant short
Gola Ghassipur	Ghassipur Orchard	round	Yellowish green	2 nd week of July	Yellow	Sweet	Sonfia	Scanty short
Jogiya Chhalli	Govt. Orchard, Bhunga	ovate oblong	Yellowish	2 nd week of July	Orange	Sweet	Pleasant	Scanty
kala Amb	Govt. Orchard, Bhunga	ovate	Green	3 rd week of July	Yellow	Sweet	Pleasant	Absent
Laddu Amb	Ghassipur Orchard	round	Yellow with red blush	3 rd week of July	Orange	Sour	Pleasant	Much short
Mahantan di Chhalli	Village Daifrar	oblong	Yellowish	2 nd week of July	Yellow	Sweet	Sonfia	Abundant long
Mahantan di lalrain	Village Daifrar	ovate	Light yellow	3 rd week of July	Yellow	Sweet	pleasant	Much short
Pencil Amb	Inami Bagh	oblong	Yellow with apple blush	2 nd week of July	Cream	Sweet	Pleasant	Abundant short
Pirh wala Amb	Village Chohal (Road side)	ovate	Yellowish green	2 nd week of July	Creamish	very sweet	aromatic	Abundant short
Rasbhari	Village Daifrar	oblong	Yellow	4 th week of July	Lemon	very sweet	pleasant	Abundant short
Shashi Amb	Village Chohal	oblong	Greenish yellow with reddish tinge	3 rd week of July	Orange	very sweet	Pleasant	Absent
Sindhuri Chusa	Adia Orchard, Hariana Town	oblong	Yellow with red blush	2 nd week of July	light yellow	very sweet	Pleasant	Sparse
Thudi Amb	Adia Orchard, Hariana Town	Oblong ovate	Greenish	3 rd week of July	light yellow	Sweet	Pleasant	Abundant short
Tota pari	Village Kukanate	ovate oblong	Greenish yellow	2 nd week of July	Orange	Very sweet	sonfia	Scanty

Table 2. Comparison of fruit size and weight in different sucking mango varieties in district Hoshiarpur

Strains	Fruit weight (g)	Fruit length (cm)	Fruit breadth (cm)	Pulp weight (g)	Pulp (%)	Peel weight (g)	Peel (%)	Stone weight (g)	Stone (%)	Pulp/stone ratio
Achari Gola	296.5	10.07	7.77	186.1	62.8	45.9	15.5	64.5	21.8	2.89
Anami Amb	99.8	7.22	4.59	39.8	39.9	27.2	27.3	32.8	32.9	1.21
Anami Chhalli	175.7	10.27	5.57	104.5	59.5	26.5	15.1	44.7	25.4	2.34
Anda Dushehree	60.1	6.75	4.63	22.2	36.9	18.5	30.8	19.4	32.3	1.14
Arru amb	110.0	6.01	5.55	68.0	61.8	22.8	20.7	19.2	17.5	3.54
Banta Amb No. 1	212.7	9.09	6.58	103.2	48.5	55.6	26.1	53.9	25.3	1.91
Banta Amb No. 2	142.5	7.52	5.52	71.5	50.2	30.7	21.5	40.3	28.3	1.77
Banta Amb No. 3	138.0	7.43	6.04	65.5	47.5	32.7	23.7	39.8	28.8	1.65
Ber Amb	50.3	4.63	3.83	18.3	36.4	12.6	25.1	19.4	38.6	0.94
Bhagva Chhalli	185.2	10.04	5.59	122.5	66.1	25.5	13.8	37.2	20.1	3.29
Chhalli No. 18	110.4	9.29	5.24	46.1	41.8	27.1	24.5	37.2	33.8	1.24
Charan Achari	162.3	7.51	5.79	106.1	65.4	27.5	16.9	28.7	17.7	3.70
Choe Sindhuri	111.6	7.52	5.01	61.4	55.0	19.3	17.3	30.9	27.7	1.99
Ghassipur Amb	95.5	6.73	5.01	48.9	51.2	16.5	17.3	30.1	31.5	1.62
Gola Desi	220.2	8.01	6.52	153.2	69.6	27.3	12.4	39.7	18.0	3.86
Gola Ghassipur	170.7	7.22	6.26	96.5	56.5	39.5	23.1	34.7	20.3	2.78
Jogiya Chhalli	380.4	12.52	7.51	267.5	70.3	60.8	16.0	52.1	13.7	5.13
Kala Amb	64.6	6.09	4.55	29.0	44.9	12.5	19.4	23.1	35.8	1.26
Laddu Amb	97.5	6.03	5.09	50.5	51.8	20.5	21.0	26.5	27.2	1.91
Mahantan di Chhalli	163.2	9.51	5.60	67.2	41.2	46.6	28.6	49.4	30.3	1.36
Mahantan di laltain	142.9	7.20	5.53	64.5	45.4	33.9	23.2	44.5	31.3	1.45
Pencil Amb	119.7	7.53	5.04	75.8	63.3	19.0	15.9	24.9	20.8	3.04
Pirh wala Amb	99.1	6.50	5.25	51.4	51.9	17.2	17.4	30.5	30.8	1.69
Rasbhari	106.5	7.07	5.50	57.3	53.8	21.4	20.1	27.8	26.1	2.06
Shashi Amb	192.1	9.27	6.47	120.5	62.7	37.6	19.6	34.0	17.7	3.54
Sindhuri Chusa	90.6	7.21	4.54	53.4	58.9	17.1	18.9	20.1	22.2	2.66
Thudi Amb	248.5	11.57	6.56	155.5	62.6	48.1	19.4	44.9	18.1	3.46
Tota pari	120.9	7.52	5.01	63.5	52.5	23.3	19.3	34.1	28.2	1.86
C.V. (%)	49.4	22.5	16.1	64.4	18.2	44.0	22.5	32.5	25.2	44.8

Table 3. Physico-chemical attributes of different sucking mango varieties in district Hoshiarpur

Strains	Stone length (cm)	Stone breadth (cm)	TSS (%)	Acidity (%)	TSS/acid ratio	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)
Achhari Gola	8.60	4.52	15.2	0.51	29.8	10.30	3.63	6.34
Anami Amb	6.25	4.05	15.9	0.51	31.2	13.80	4.14	9.18
Anami Chhalli	9.18	3.74	15.2	0.51	29.8	12.14	3.41	8.29
Anda Dushehree	5.74	2.57	17.8	0.32	55.6	15.97	4.31	11.08
Arru amb	4.75	3.27	15.2	0.54	28.1	12.73	3.40	8.86
Banta Amb No. 1	6.58	4.23	13.9	1.28	10.9	10.09	2.23	7.47
Banta Amb No. 2	6.02	3.55	13.4	0.74	18.1	8.51	3.82	4.46
Banta Amb No. 3	5.50	3.64	14.2	0.96	14.8	11.20	2.99	7.80
Ber Amb	4.48	3.08	21.1	0.25	84.4	16.08	4.77	10.74
Bhagva Chhalli	9.41	4.26	15.9	0.51	31.2	14.10	3.20	10.36
Chhalli No. 18	8.15	4.25	19.1	0.38	50.3	14.92	5.33	9.11
Charan Achari	6.06	3.53	14.2	1.81	7.90	10.20	2.68	7.14
Choe Sindhuri	6.55	3.99	13.6	0.76	17.0	11.71	2.15	9.08
Ghassipur Amb	5.81	3.52	17.6	0.38	46.3	16.03	4.46	10.99
Gola Desi	7.25	4.22	14.2	0.45	31.6	11.56	4.00	7.18
Gola Ghassipur	5.44	4.07	12.4	0.83	14.9	8.62	2.95	5.39
Jogiya Chhalli	10.34	3.62	13.8	0.42	32.9	10.53	2.15	7.96
kala Amb	5.74	3.05	10.4	0.54	19.3	9.46	2.39	6.72
Laddu Amb	5.23	3.58	14.4	0.86	16.7	11.56	2.42	8.68
Mahantan di Chhalli	9.09	4.22	13.5	0.80	16.9	10.57	2.72	7.46
Mahantan di laltain	6.52	4.04	16.2	1.12	14.5	13.99	2.99	10.45
Pencil Amb	6.71	4.01	14.4	0.45	32.0	10.85	3.41	7.07
Pirh wala Amb	6.03	3.58	14.2	0.42	33.8	12.26	3.40	8.42
Rasbhari	5.87	4.21	17.5	0.44	41.7	12.90	3.27	9.15
Shashi Amb	8.57	4.08	15.8	0.38	41.6	12.17	3.90	7.86
Sindhuri Chusa	6.01	3.17	16.2	0.42	38.6	10.49	2.71	7.39
thudi Amb	10.02	4.56	14.0	0.53	25.9	11.56	2.64	8.47
Tota pari	5.88	3.99	17.6	0.45	39.1	13.78	3.20	10.05
C.V. (%)	23.9	12.6	14.2	53.9	53.1	17.6	24.6	19.7

Jogiya Chhalli. This attribute can be used for selection of varieties that has potentially to be exploited for juice and canning industry. Further, strains like *Charan Achari*, *Gola Desi* and *Banta strains No.1, 2 and 3* could be conserved and exploited for further used as pickle type of mangoes on account of their higher juice acid per cent, pulp/stone ratio, sour-sweet taste, almost roundish shape and medium to abundant fibres content. Fruit pulp per cent recovery next to strain *Jogiya Challi* was observed in *Gola Desi* (69.6) followed by *Bhagva Chhalli* (66.1) and minimum (36.4) in *Ber Amb*.

Besides, *Jogiya Chhalli*, higher in fruit length and oblong shaped mango strains was also found in *Thudi Amb*, *Anami Chhalli*, *Achhari Gola* and *Bhagva Chhalli*. On the contrary, maximum fruit breadth was observed in *Achhari Gola* and minimum fruit size in *Ber Amb*.

Strains-*Thudi Amb*, *Bhagva Chhalli*, *Anami Chhalli* and *Mahatan di Chhalli* had stone length of 10.02 cm, 9.41 cm, 9.18 cm and 9.09 cm, respectively. Although, fruit size and pulp/stone ratio of elite mango strains *Ber Amb*, *Anda Dushree* is uneconomical, but juice contained appreciably higher percentage of soluble solids and total sugars with sweet taste. Fruit weight showed significant positive correlation with fruit size, pulp weight, stone weight, peel weight, pulp content, pulp/stone ratio and stone size (Table 4). However, it exhibited negative significant correlation with fruit stone content. Significant negative correlations were also recorded for fruit weight, fruit breadth, pulp weight, peel weight, pulp/stone ratio with total sugars content of the fruit. Total soluble solids in juice showed significant positive correlation with total sugars (0.88) and reducing sugars (0.62), and negative

correlation with juice acid content (-0.47).

Variability in chemical attributes of fruits was also found among different mango strains (Table 2). The highest total soluble solids in juice were observed in *Ber Amb* (21.1%), and also possessed very sweet, aromatic, thin juice consistency and superb fruit taste. Brix per cent of the juice ranged from 12.4 to 13.8 in *Gola Ghassipur*, *Choe Sindhuri*, *Mahantan di Chhalli*, *Jogiya Chhalli* and *Banta Amb No. 1*. The Juice acid content (%) was maximum in *Charan Achari*, followed by *Banta Amb No. 1*, *Mahantan di laltain* and minimum in *Ber Amb*. TSS/acid ratio in different selected strains ranged from 7.9 in *Charan Achari* to 84.4 in *Ber Amb*. Total sugar per cent was estimated to be highest in *Ber Amb* followed by *Ghassipur di Chhalli* and minimum in *Banta No. 2*. Sweetness and taste of mango juice is mainly contributed by the presence of reducing sugars per cent and it was maximum in *Chhalli No. 18* values were 5.33 per cent. Non-reducing sugars per cent also showed considerable variability in different strains and it ranged from 4.46 to 11.08.

Old records, mentioned dated back to the early nineteenth century by Captain Montgomery in Hoshiarpur District Gazetteer (Anonymous, 1914) reported that a large number of mango varieties/strains/landraces were grown in the region. These include Panchpaya mango: large fruit, said to weigh five quarters (*panch pao*) of a kacha ser, equal to one pound avoirdupois; the *Kharbusa*: fruit average size, inside colour supposed to be like a musk melon (*kharbusa*); the *Kasumbla*: Small fruit, outer colour like safflower (*kasumba*); the *basantia*: small fruit, inner colour yellow (*basanill*); the *Pera*: small and very sweet, supposed to be in shape and taste like the sweetmeat pera; the *Dihalu*: large fruit, inside like curds (*dahi*), and not stringy; the *Marabla*: large fruit, sweet, with a small stone used principally for making preserves (*maraba*); the *Pathar*: fruit average size, supposed to be like a stone (*pathar*) in weight and hardness of its skin, keeps for a long time; the *Laler*: shape like a coconut: fruit, large and sweet; the *Bhadauria*: average size, ripens in the month of Bhadon (September), after other mangoes are over; the *Sandhuria*: average size so called on account of its red (*sandur*) colour; the *Kesari*: large fruit, colour saffron (*Kesar*); the *kela*: long fruit like a plantain (*kela*), with a large stone; the *Misri*: large fruit, sweetest sugar (*misri*); the *Jawainia*: the large fruit, smells like aniseed (*ajwain*); the *Shahatia*: large fruit, sweet as honey (*shahad*); the

Gora: large and brown like the bolls made up of cleaned cotton. The above species fetched the highest prices, especially the *Bhadauria* as being in the market when no other fruits are available in the market. The remainder fruits, which were less consideration are; *Saru*: small fruit, very quickly rots (*sorjala*); the *Harar*: small like the fruit of harar (*Terminalia chebula*); the *Dohki*: small with a strong taste of turpentine; the *Sufeda*: small and of a white colour; the *Rara*: small and sweet in size like the fruit of the bahera (*T. bellerica*); the *khala*: average size, bad colour and acid (*khata*) taste; the *kala*: average size, dark coloured skin even when ripe; the *Laichi*: small fruit, grows in clusters said to smell like cardamom (*ilaichi*); the *Dodhia*: small, white inside like milk (*dudh*); the *Chhali*: long fruit like maize cob; the *Kakra*: large long fruit, origin of name unknown.

None of mango seedlings except '*Sandhuria*' and '*Chhalli*' strains like characteristics were found during the present survey; indicating that the natural mango diversity has declined or vanishing in the region. In the present study, higher estimates for coefficient of variation with regard to various qualitative and quantitative characters indicated that a greater variability exist among different strains. There is an ample scope for crop improvement through direct selection of elite mango genotypes available in the different diversity regions. Variability in various physico-chemical attributes is due to inherent genetic capacity of different mango cultivars and also depends upon their phenotypic expression in a particular ecological zone (Singh and Chadha, 1981). Dash and Hota (1977) reported that soluble solids character in elite selected strains was highly heritable, therefore, strains possess higher TSS can be selected as donor or utilized as parent in hybridization programme. Navprem and Sharma (2007) evaluated sucking types of mangoes under sub mountane zone of eastern Punjab (India) conditions and reported a wide variation in respect of fruit shape, size, pulp colour, TSS, acidity, malformation etc.

It was noted that fruit colour ranged from attractive yellow with red blush on the shoulders, fully coloured, yellowish, light yellow, deep chrome and greenish among selected mango strains and these can be used as a donor source for developing coloured mango hybrid cultivars. Sharma and Majumdar (1989) revealed that red skin colour of the fruit is dominant and it has been governed by duplicate gene thereby showed various gradation of pink blush on the fruits in progeny population. The natural deep fruit pulp colour may be utilized for substitution of

Table 4. Correlation studies among different Physico-Chemicals attributes in mango

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	0.83**	0.89**	0.98**	0.81**	0.85**	0.63**	-0.32	-0.70**	0.73**	0.68**	0.48**	-0.29	0.13	-0.29	-0.35	-0.32	-0.26
2	1.00	0.69**	0.79**	0.73**	0.73**	0.49**	-0.23	-0.55**	0.54**	0.89**	0.50**	-0.11	-0.02	-0.17	-0.11	-0.12	-0.07
3	1.00	0.84**	0.78**	0.78**	0.83**	0.56**	-0.22	-0.68**	0.62**	0.49**	0.51**	-0.24	0.18	-0.33*	-0.33*	-0.26	-0.27
4	1.00	0.69**	1.00	0.69**	0.74**	0.75**	-0.46**	-0.77**	0.83**	0.66**	0.39*	-0.28	0.07	-0.24	-0.34*	-0.30	-0.26
5	1.00	0.82**	0.23	1.00	0.82**	0.23	-0.10	-0.27	0.23	0.62**	0.58**	-0.18	0.19	-0.31	-0.23	-0.21	-0.18
6	1.00	0.25	0.17	0.25	1.00	0.25	0.17	-0.50**	0.43**	0.55**	0.55**	-0.28	0.27	-0.35*	-0.35*	-0.39*	-0.23
7	1.00	1.00	1.00	1.00	1.00	1.00	-0.81**	-0.90**	0.92**	0.43**	0.25	-0.24	0.05	-0.24	-0.31	-0.24	-0.26
8	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.47**	-0.58**	-0.29	-0.06	0.11	0.11	0.06	0.13	0.03	0.15
9	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.95**	-0.43**	-0.33**	0.28	-0.15	0.31	0.37*	0.33*	0.28
10	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.45**	0.20	0.20	-0.29	0.08	-0.23	-0.35*	-0.29	-0.28
11	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.54**	0.03	0.03	0.03	-0.18	0.04	0.05	-0.08	0.10
12	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.06	1.00	0.06	-0.01	-0.06	0.01	-0.21	0.11
13	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.47**	0.85**	0.88**	0.62**	0.76**
14	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.75**	-0.49**	-0.45**	-0.37*
15	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.76**	0.56**	0.64**
16	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.60**	0.92**
17	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.23
18	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

1. Fruit weight 2. Fruit length 3. Fruit breadth 4. Fruit pulp weight 5. Fruit stone weight 6. Fruit peel weight 7. Fruit pulp (%) 8. Fruit peel (%)
9. Fruit stone (%) 10. Pulp/stone ratio 11. Stone length 12. Stone breadth 13. TSS (%) 14. Acidity (%) 15. TSS/acid ratio 16. Total sugars (%)
17. Reducing sugars (%) 18 Non-reducing sugars (%)

** Significant at P < 0.01

* Significant at P < 0.05

synthetic colour in preservation industry. Kumar (2000) reported that pulp colour of the fruit was not influenced by the environment and it was controlled by genetical make up. Fruits with good flavour and taste are in great demand in both domestic and international market, hence, mango seedlings population in the region will be further screened for the selection as strains in crop improvement. Presence of fine fibres are a necessity to protect the interior of a fruit from bruising and internal collapse during handling and shipping, however, abundance of fibre content are not acceptable to the consumer (Iyer, 1991). Hence, the existing mango seedlings population in the region not only adds to biological diversity but can also be utilized in different mango breeding programme for developing superior varieties.

On the basis of fruit maturity, these strains were classified into three groups i.e., early season, mid season and late season. Availability of mango fruits under north Indian conditions of Punjab commence from 1st fortnight of July to the end of August, consequently, late maturing strains fetch good market price because of their availability at fag end of the season. Mango fruits on the basis of fruit shape and size were classified as ovate, oblong, round and ovate-oblong. Wide variability was recorded in fruits for the presence of flavour, taste and aroma at the time of ripening; this can be exploited for identifying sucking, pickle and table purposes mango strains. Several workers also described the promising local mango seedling with respect to physico-chemical attributes under different agro-climatic conditions of India (Teotia and Singh, 1963; Rabbani and Singh, 1989; Parida and Rao, 1989; Navprem and Sharma, 2007). In the present survey, it was felt that demand for sucking and pickles type has been escalated in the region due to decrease in seedlings mango population.

During the survey, it was observed that indigenous mango seedlings population in the region is declining owing to poor management practices in general and occurrence of insects-pests and diseases in particular i.e. stem borer *Batocera rufomaculata* (de Geer), mango hopper *Amritodus atkinsoni* (Lethierry), mango mealy bug *Drosicha mangiferae* (Green), mango scale *Aspidiotus destructor* (Signoret), shoot borer *Chlumetia transversa* (Walker) and dieback (*Botryodiplodia theiobromae*). Efforts are being made to declare nearly 150 years old mango seedlings orchard known as 'Inami Bagh' spread over 12 acres at village Bassi Umar Khan Hoshiarpur as 'Biodiversity Heritage Site'

for *in situ* conservation and to prevent genetic erosion of rare indigenous mango plantation. Indigenous mango seedlings are presently conserved mainly due to religious beliefs, growing along strips of roads, railway lines, canals/drains and restriction imposed on felling of trees over the Shiwalik areas of Punjab under section 4 & 5 of the Land Preservation Act 1900. These studies showed that there exists a great variability among different mango seedling progeny and this can be exploited for the selection of elite genotypes in future after evaluating their performance.

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