Research Article

Trade Potential Evaluation of Indigenous and Exotic Mango Genotypes Through Physico-chemical and Sensory Attributes

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Abstract | Despite the immense market and growing demand of Pakistani mango, there has been a rapid decrease in the production and export of mango in the last few years. Low yield and poor quality are considered the major limiting factors in export. Therefore, some high yielding good quality exotic mango cultivars were acclimatized in the country and a comprehensive research studies were executed to investigate the yield potential, fruit physico-chemical characters and sensorial aspects. Diverse seventeen commercial and noncommercial indigenous and exotic mango varieties were selected to collect and analyze fruit morphological data under randomized complete block design (RCBD). There was significantly high fruit weight and pulp contents in 'Kensington Pride'. Total soluble solids (TSS) were higher (21.9 B°) in 'Chaunsa', while, titratable acidity (TA) was lowest in 'Lambay Alfansu' and 'Momi-K'. However, reducing sugars (RS) (4.83%), non-reducing sugars (NRS) (16.38%) and total sugars (TS) (21.21%) were significantly high in 'Surkha Burma'. Ascorbic acid contents (AA) were high in 'Momi-K', whereas, total antioxidants (0.68 mM Trolox g^{-1}), total carotenoids (TC) (52.0 µg 100^{-1}) and flavonoids (1.79 µg 100^{-1}) were significantly high in 'Faisalabad Selection'. Faisalabad Selection and 'Surkha Burma' exhibited high score for taste, flavor, texture, aroma and pulp color compared to other indigenous and exotic varieties. It is concluded that 'Faisalabad Selection', 'Surkha Burma' and 'Kensington Pride' among indigenous and exotic varieties, respectively, had potential in commercial trading and can expend the supply window of mango.

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Introduction

Mango (*Mangifera indica* L.) "King of fruits" is a vital fruit of tropical/sub-tropical areas, originated in the premises of Indo-Burma region and grown in more than 100 countries around the world (Sauco, 1997; Rajwana et al., 2011). Mango is a commercial fruit crop of several countries including Pakistan, India, Philippines, Indonesia, Malaysia, Thailand and Burma (Singh and Rajan, 2009). Being

major mango growing country of the world Pakistan produces 1.7 million tons of mangoes on an area of 151.5 thousand hectares and is ranked as 5th leading mango growing and 3rd prominent mango exporting country with an annual export of 80,000 tons. Punjab and Sindh is the leading mango growing Provinces of the country with annual share of 67% and 32%, respectively (Rajwana et al., 2011).

It has been reported that over 260 mango varieties are cultivated in Pakistan till four decades ago but in few earlier years mango genetic resources are decreasing due to rapid population increase and prompt industrialization (Rajwana et al., 2007), which resulted rapid reduction in varietal spectrum with narrow harvesting window, however, mango productivity could be improved through cultural practices by reducing malformation of inflorescence (Anwar et al., 2011 and Nafees et al., 2010) and wilting of shoots (Nafees et al., 2013) . To overcome these constraints some of the leading exotic mango cultivars have been introduced in the country. Moreover, several foreign origin mango varieties are available in the country but proper information about their physico-chemical quality/value is lacking. Furthermore, it is indispensable to capitalize the increased demand of mango both in national and international markets by increasing the production potential with yielding cultivars (Amin et al., 2008). Moreover, despite the immense growing demand for different mango varieties of Pakistan in the Western markets there has been a rapid decrease in the production and export of mango in the last few years. Low yield and poor quality mango production are the major factors for decline in export (Jamil et al., 2015). Some of the crucial components that contribute for the acceptance of high quality fresh mangoes by the consumer are taste, flavor, aroma volatiles, textural characteristics and biochemical attributes (Berghofer, 2008). Different quality parameters that influence the consumer perception are fruit size, shape, color, TSS, acidity, fruit pulp contents, and pulp peel ratio for table purposes and value addition (Jamil et al., 2015: Rajwana et al., 2011). Moreover, acceptance for the color, taste and flavor of mango fruits is substantially imperative throughout the world that increases its import potential. Fruit developmental changes like physical and biochemical traits are important for the premium quality of mango varieties that ultimately contributes in the selection of the fruit based on the perception of consumers (Berghofer, 2008; Akhter et al., 2009). Moreover, sensory profile of mango has a great impact on consumer's decision to buy a particular type of fruit or its products (Gossinger et al., 2009). In the past some promising cultivars of mango have been introduced in the country from various regions of the world but no planned study has been reported regarding their yield potential and physico-chemical and sensorial attributes.

Therefore, a comprehensive study was conducted to investigate the yield potential, fruit physico-chemical characteristics and sensorial aspects of different exotic and indigenous mango cultivars to broaden the supply window of mango fruit in the country to earn precious foreign exchange. Moreover, germplasm characterization and conservation will provide information for variety improvement program.

Materials and Methods

The research studies were conducted at Experimental Fruit Garden, Square No. 32, Institute of Horticulture Sciences, University of Agriculture Faisalabad, Pakistan during 2011-13. Experiment was laid out in RCBD with four replications. Among seventeen selected varieties: 'Burma Surkha', 'Faisalabad Selection', SS-2, 'Haider Shah', 'Saleh Bhai' 'Golden Lahotia' and 'Sanglakhi' are local non-commercial; 'Chaunsa', 'Dushehari'; 'Sindhri and Lambay Alfansu' are commercial while, 'Momi-K'; Almas'; 'Collector', 'Early Gold'; 'Kensington Pride and 'Sensation' are exotic with six to eight years old plants of each, growing in uniform agro-climatic conditions of Fruit Experimental Area of University of Agriculture Faisalabad. All selected varieties were grafted on wild seedling mango, planted in square system with 20 meters plant to plant and row to row distance.

Fruit physical characteristics

After harvest at optimum physiological maturity fruit were ripened at ambient temperature conditions (25±2 °C and 65–70% RH). Fruit, peel, pulp and stone weight of each sample was measured with digital weight balance and expressed in grams.

Fruit biochemical characteristics

Total soluble solids (tss) and titratable acidity (ta): A hand refractometer (2522) was utilized for the estimation of TSS (in °Brix). One to two drops of juice sample was placed on the prism of the refractometer, the lid was closed and TSS were noted directly from the scale and measurements were recorded as report-

ed (Hortwitz, 1960). Ten mL of juice sample was taken in a beaker, diluted (1:4) with double distilled water and titrated against N/10 NaOH using phenolphthalein as an indicator. The acidity was expressed as percent citric acid.

The ratio TSS: TA (sugar: acid) was calculated by dividing TSS value with corresponding acidity percentage.

Ascorbic acid

Juice of the fruit was extracted from 20 fruits and homogenized comprehensively (Ullah et al., 2012). Ten mL of the extracted fruit juice was transferred into 100 mL flask and volume of the flask was made up to mark by adding solution of 0.4% of oxalic acid. Five mL of the filtrated aliquot was taken and titrated against 2, 6-dichlorophenolindophenol, till the persistent light pink color end point and expressed as mg 100 g^{-1} of fruit weight (Ullah et al., 2012).

Sugars

Sugars such as reducing, non-reducing and total sugars were estimated by taking 10 mL of juice in 250 mL flask in which 100 mL distilled water, 25 mL lead acetate solution (430 g 1000 mL^{-1}) and 10 mL of 20% potassium oxalate solution was added. Volume was made up to the mark with distilled water and contents were filtered. Then the filtrate was used for the estimation of sugars as reported and were expressed in percentage (Shafiq et al., 2011). The above mentioned filtrate was taken in burette and titrated against 10 mL Fehling's solution using 2-3 drops of Methylene blue with continuous boiling till brick red end point appeared. Reducing sugars (RS) were calculated by: % reducing sugars: 6.25 (X/Y) where X: mL of standard sugar solution used against 10 mL Fehling's solution; Y: mL of sample aliquot used against 10 mL Fehling's solution (Lalel et al., 2003).

Total carotenoids

One gram of the fruit pulp was blended with 0.05 g $MgCO_3$ in silica sand by using pestle mortar and it was centrifuged at 5,000 rpm in centrifuge machine. Extraction was made twice with help of acetone: n-hexane (75:60 v/v) mixture (20 mL $sample^{-1}$). The extract was obtained in separating funnel and carefully rinsed with a 40 mL of 10% NaCl and 80 mL double distilled water to eliminate impurities of acetone from the extracted sample. The hexane extract was fed to the spectrophotometer (Thermo Electron Corporation, Waltham, USA) at 436 nm wavelength to determine its absorbance and was expressed as µg mL^{-1} of β-carotene equivalent by using standard curve of β-carotene (Lalel et al., 2003).

Phenolic contents

Mango fruit pulp (1 g) was grounded in pestle mortar and extracted 100 µL was transferred in an eppendorf tube, 200 µL 10% *Folin–Ciocalteu reagent* (FCR) was add and vortexed thoroughly for one min. Then 800 µL of Na_2CO_3 was added in each tube and again vortexed for thirty sec and the tubes were incubated at room temperature for 1-2 h. A blank sample was also prepared by using 100 µL extraction mixtures instead of the juice sample and run independently. Finally 200 µL samples were transferred to a clear micro plate and absorbance was taken at 765 nm wave length in spectrophotometer (Thermo Electron Corporation, Waltham, USA) and expressed as µg mL^{-1} fresh weight (FW) (Ullah et al., 2012).

Total antioxidants

Fruit pulp (1 g) was grounded and 50 µL extract was added to 5 mL 0.004% of methanol solution of DPPH. After 30 min incubation at room temperature and then absorbance was measured at 517 nm in spectrophotometer (Thermo Electron Corporation, Waltham, USA). Then same procedure was repeated by taking 100 µL and 150 µl extracts and expressed as mM Trolox g^{-1} fruit weight (Shafiq et al., 2011).

Total flavonoid contents

Colorimetric aluminum chloride method was used for the estimation of flavonoid contents in mango as µg 100 g^{-1} fruit weight. Briefly, 0.5 mL solution of each plant extracts in methanol were separately mixed with 1.5 mL of methanol, 0.1 mL of 10% aluminum chloride, 0.1 mL of 1 M potassium acetate, and 2.8 mL of distilled water, and left at room temperature for 30 minutes. The absorbance of the reaction mixture was measured at 415 nm with a double beam Perkin Elmer UV/Visible spectrophotometer (USA). Total flavonoid contents were calculated as quercetin from a calibration curve. The calibration curve was prepared by preparing quercetin solutions at concentrations 12.5 to 100 mg ml^{-1} in methanol (Ebrahimzadeh et al., 2008).

Organoleptic evaluation

Organoleptic evaluation was made subjectively from a panel of ten trained experts (6 male and 4 female)

Table 1: *Yield attributes and fruit physical characteristics of selected mango cultivars.*

	Cultivars	Yield per tree	Fruit weight	Pulp weight	Peel weight	Stone weight
		(kg)	(g)	(g)	(g)	(g)
Indi Com.	Chaunsa	87a	173.33i	99.76i	34.86g	36.83c
	Sindhri	88a	193.66f	129.36e	23.13j	35.36d
	Dusehri	67b	90.43o	47.10m	17.76k	21.50h
Indi Non-Com	Faisalabad Selection	61c	106.96n	46.60m	31.90i	27.13g
	Burma Surkha	64b	124.00l	127.33f	18.66k	30.20f
	Lambay Alfansu	45e	237.16c	144.46c	53.13b	37.66bc
	Sanghlakhi	52d	209.96e	123.33g	48.00c	33.16e
	SS-2	49e	89.10o	50.36l	12.43l	28.23g
	Golden Lahotia	58c	177.20h	100.53i	43.33e	32.36e
	Haider Shah	60c	116.33m	50.36l	33.13h	30.43f
	Saleh Bhai	39f	172.83ij	87.60j	45.13d	35.53d
Ex.C.	Kensington Pride	89a	305.73a	188.30a	62.56a	46.00a
	Sensation	49e	140.00k	67.00k	36.66f	35.33d
Exotic Non-commercial	Momi-K	43f	216.06d	137.76d	36.53f	38.65b
	Collector	54d	180.50g	109.83h	32.06hi	38.40b
	Early Gold	59c	171.60j	100.40i	35.00g	34.90d
	Almas	45e	244.60b	172.20b	32.50hi	37.70bc
	LSD (P ≤ 0.05)	5.316	6.274	4.961	2.342	2.021

LSD: *Least significant difference. Any two means not sharing same letter differ significantly (P ≤ 0.05); in columns, values sharing similar letters are statistically not different. Abbreviations: Indi Com. (Indigenous commercial); Ex.C. (Exotic commercial).*

for both years from postharvest staff and postgraduate students following nine point hedonic scales (Peryam and Pilgrim, 1957).

Statistical analysis

All physical, chemical and sensory data was analyzed statistically in MSTAT-C software. An analysis of variance technique was employed to test the significance of data, while, Duncan's New Multiple Range Test (DMRT) was used to compare the differences among treatment means at $p < 5\%$ (Steel et al., 1997).

Results and Discussion

Physical fruit characteristics

There was statistically significant difference among all varieties for fruit yield, per plant and fruit, pulp, peel and stone weight ($P \leq 0.05$), however, highest fruit yield was exhibited in 'Kensington Pride' (89 kg/ tree) yield which was statistically at par with Chaunsa (87 kg/tree and Sindhri 88kg/tree , whereas, 'Saleh Bhai' gave minimum yield (39 kg/ tree) (Table 1). Yield of Burma Surkha, Dushehari and Faisalabad selection was above 60 kg/ plant and proved second highest yield in selected varieties. Highly significant single fruit weight (305.73 g) was recorded in 'Kensington Pride' and surpassed all other cultivars, while, 'SS-2' revealed lowest (89.10 g) fruit weight (Table 1). Highest pulp weight (188.3 g) was recorded in 'Kensington Pride' followed by Lambay Alfansu (172 g) and Almas (144 g) whereas, 'Faisalabad Selection' had least pulp weight (46.6 g) (Table 1). Statistically, lowest stone weight (21.5 g) was recorded in 'Dushehari' whereas, 'Kensington Pride' had highest value (46 g).

Fruit size and weight are important factor for fresh market of mango fruits because both consumers and pulp processing industry demand medium to large size fruits. Significantly high variation in fruit weight in selected genotypes is accord to the finding of other mango genotypes (Chanana et al., 2005; Ibrahim et al., 2005). Therefore, fruit weight is genotype dependent trait which may further be affected by agro-climatic conditions of specific production areas. Pulp weight is also very important because consumers as well as processing industry demand cultivars with high pulp or pulp/stone ratio. Pulp contents usually

Table 2: *Fruit biochemical characteristics of different indigenous and exotic mango cultivars.*

Cultivars		TSS (°Brix)	TA (%)	TSS:TA (Ratio)	RS (%)	NRS (%)	TS (%)
Indi.Com.	Chaunsa	21.9a	0.24e	91.50ab	2.52def	11.24bc	13.76b
	Dushehari	18.0d	0.20g	88.93bc	3.22b	5.79ef	9.01def
	Sindhri	14.0h	0.15i	95.77a	2.66de	11.48b	14.14b
Indi Non-Com.	Lambay Alfansu	17.0e	0.1h	96.09a	1.86h	8.08cde	9.94cde
	Faisalabad Selection	19.0c	0.20g	94.94a	2.05gh	8.81bcde	10.86bcde
	Golden Lahotia	15.0g	0.20fg	73.52d	2.06gh	11.48b	13.54b
	Saleh Bhai	15.2g	0.24 e	83.88c	2.30defgh	11.35b	13.65b
	Sanghlakhi	18.0d	0.30 c	58.82e	2.37defg	10.34bcd	12.71bc
	Haider Shah	16.0f	0.22 f	72.87d	2.11fgh	10.12bcd	12.23bcd
	Burma Surkha	20.0b	0.20fg	73.77d	4.83a	16.38a	21.21a
	SS-2	18.0d	0.25 e	70.78d	2.23efgh	11.34b	13.57b
Exotic Commercial.	Kensington Pride	19.0c	0.36 b	52.79f	2.00gh	6.03ef	8.03ef
	Sensation	12.0i	0.28 d	43.11g	3.44b	7.49de	10.93bcde
Exotic non-commercial	Momi-K	15.0g	0.17 h	85.21ab	2.75cd	6.28ef	9.03def
	Collector	16.0f	0.18 h	89.18ab	2.21efgh	3.88f	6.09f
	Early Gold	17.8d	0.21fg	84.87c	2.41defg	9.73bcd	12.14bcd
	Almas	17.0e	0.38 a	44.76g	3.19bc	6.18ef	9.37def
LSD (P ≤ 0.05)		1.427	1.088	3.572	0.973	1.470	2.391

TSS: *total soluble solids;* **TA:** *titratable acidity;* **AA:** *ascorbic acid;* **RS:** *reducing sugars;* **NRS:** *non-reducing sugars;* **TS:** *total sugars. Any two means not sharing same letter differ significantly at 5% probability. Column values sharing similar letters are not different statistically (P ≤ 0.05).*

depend on fruit size and larger fruit ultimately contribute more pulp but it also varies with cultivar to cultivar. Contrary to our findings, (Chanana et al., 2005) reported pulp weight (59.67 g) and (301 g) in 'SS-II' whereas and 'Sindhri', respectively which proved that pulp contents are genotype related trait. Lowest (12.43 g) peel weight was found in 'SS-II', while, 'Kensington Pride' exhibited highest (62.56 g) peel weight (Table 1). Peel weight usually varies with hereditary characteristics of fruits depending on genotypes. Thick skin besides contributing more skin weight also has an advantage of more shelf life thus successfully be exported to distant markets. Similar to our findings, (Wahdan et al., 2011) also observed significant variations regarding peel weight as highest peel weight was found in 'Sindhri' (42.67 g) compared to 'SS-2' (20.67 g). Contradictory to our findings, (Rodriguez-Pleguezuelo et al., 2012) found significant variations in stone weight with highest (11.8 g) in 'Kensington Pride' and lowest (4.2 g) in 'Osteen'. This variation may be accredited only for genetic make-up of cultivars because environmental condition and cultural practices are similar for all selected genotypes. More stone weight is limiting factor as only mango cultivars with more stone/pulp ratio cannot fetch consumer attraction as people are usually willing to buy fruit with low stone weight of high pulp/stone ratio.

Fruit biochemical attributes

Statistically, significant difference was recorded among selected mango genotypes for various level of Total soluble solids, Titratable acidity and various sugar contents as shown in Table 2 ($P \leq 0.05$). was found Highest TSS value (21.9 °Brix) was recorded in 'Chaunsa' among all indigenous and exotic varieties , whereas, 'Sensation' revealed minimum (12 °Brix)) TSS (Table 2). TA also exhibited significant *(*$P \leq 0.05$*)* differences among selected varieties. Minimum (0.15%) TA was found in 'Sindhri', while, highest (0.38%) TA was exhibited by 'Almas' (Table 2). Low TA in our case was accredited to comparatively high TSS which consequently resulted in relatively decreased TA. As far as TSS/TA ratio is concerned, 'Sensation' revealed lowest (43.11), while, 'Lambay Alfansu' exhibited highest (96.09) TSS/TA ratio (Table 2). High TSS/TA ratio may be attributed to higher TSS in contrast to low TA (Table 2).

Table 3: *Total phenolic and non-enzymatic antioxidant activities based on fruit weight.*

	Cultivars	T Antioxidant (mM Trolox g^{-1})	AA (mg 100 g^{-1})	TPC (mg 100 g^{-1})	TC (µg 100 g^{-1})	FL (µg 100 g^{-1})
Indi-Com.	Chaunsa	0.25ij	34.4d	38.7f	49.0b	1.53c
	Sindhri	0.43de	40.8a	49.9d	42.0e	1.18g
	Dushehari	0.68a	27.9f	52.1c	27.0j	1.24fg
Indi Non-Com.	Faisalabad Selection	0.56b	30.1e	44.5e	52.0a	1.39d
	Burma Surkha	0.32fghi	15.0h	59.1a	37.0gh	0.45j
	SS-2	0.46cd	27.9f	33.8i	33.6i	1.06h
	Almas	0.57b	27.9f	36.5g	51.3a	1.31e
	Golden Lahotia	0.28ghij	27.9f	44.9e	33.2i	1.57c
	Haider Shah	0.53bc	38.7b	24.4m	49.3b	1.58bc
	Saleh Bhai	0.26hij	34.4d	25.5l	45.3d	1.27ef
	Lambay Alfansu	0.33fghi	25.8g	53.7b	44.6d	1.64b
	Sanghlakhi	0.44de	34.8d	31.5j	36.3h	1.28ef
Exotic	Kensington Pride	0.34fgh	30.1e	24.8m	40.3f	1.39d
	Sensation	0.60b	13.5i	27.4k	49.3b	1.25ef
Exotic (Non-Commercial)	Momi-K	0.36ef	40.8a	25.7l	37.3g	0.53i
	Collector	0.35fg	36.5c	15.9n	46.3c	0.42j
	Early Gold	0.23j	36.5c	34.7h	44.6d	1.79a
	LSD ($P \leq 0.05$)	0.682	3.109	3.573	3.869	1.273

Ex. C: *Exotic commercial;* **Exotic Non C:** *Noncommercial;* **TA:** *antioxidants;* **AA:** *ascorbic acid;* **TPC:** *total phenolic contents;* **TC:** *total carotenoids;* **FL:** *flavonoids;* **LSD:** *Least significant difference ($P \leq 0.05$); any two means not sharing same letter differ significantly at 5% probability. Column value sharing similar letters are not different statistically ($P \leq 0.05$).*

In case of reducing sugars (RS), 'Lambay Alfansu' exhibited minimum (1.86%), whereas, 'Burma Surkha', surpassed all other cultivars with highest (4.83%) RS (Table 2), whereas, 'Collector' exhibited lowest NRS (3.88%). In contrast 'Burma Surkha', revealed highest NRS value (16.88%) (Table 2). On the other hand, total sugars (TS) were also found significantly different in all selected cultivars and lowest and highest percentage (6.09 & 21.21%) of TS was observed in 'Collector' and 'Burma Surkha', respectively (Table 2).

TSS was found high with low level of TA in pulp, therefore, 'Burma Surkha' is a good choice for export owing low TSS and suitable size because European people like mango with low sweetness. Similarly, (Akhter et al., 2009) found highest TSS in 'Chaunsa' and 'Anwar Ratool', while, 'Langra' exhibited lowest TSS. Similar to our results (Jamil et al., 2015) reported that TSS ranged from 9.5 to 29.1 °brix in indigenous mango accessions of Pakistan. Our results were strongly support the findings of (Mannan et al., 2003) as they reported that TA was ranged from 0.18% to 0.40% in 'Neelam Bori' and 'Madrazi Lota' mango, respectively. Similarly, (Rodriguez-Pleguezuelo et al., 2012) also reported similar results and stated TSS/TA ratio range of 56.4 to 96.30. Whereas, our results were contradictory to the findings of (Jamil et al., 2015) as he reported TSS/TA ratio, ranged from 19.2 to 349.8 in various indigenous mango germplasm of Pakistan. The relatively low TSS/TA values in our case compared to (Jamil et al., 2015) may be accredited to different/specific agro-climatic conditions of the orchards. As far as sugars are concerned, comparatively high TSS or low acidity resulted in relatively higher sugar percentage. Moreover, sugars also depend on cultivars based on its genetic makeup as most of the indigenous mango cultivars of Pakistan are characterized with higher sugars in contrast to exotic germplasm (Rajwana et al., 2011). Similar results have been reported by (Jamil et al., 2015) regarding NRS as he found NRS in the range of 2.6 to 20.9% in various mango accessions grown under subtropical regions of Pakistan like Multan (The hub of mango production). As far as total sugars are concerned, (Rajwana et al., 2010) reported that TS ranged from 7.30 to 23.71% in cvs. 'Faiz Kareem', 'Anwar Retool' and 'Chaunsa'. Therefore, our study confirmed that sugar percentage is genotype dependent trait.

Enzymatic activities

Substantial variations have been observed as far as antioxidants are concerned and cultivar 'Early Gold' exhibited minimum (0.23 mM Trolox g^{-1}) total antioxidants. On the other hand, 'Faisalabad Selection' excelled with highest (0.68 mM Trolox g^{-1}) antioxidants (Table 3). Ascorbic acid contents are important non-enzymatic antioxidant with significant differences in 'Sindhri' and 'Momi-K' excelled with highest value (48.8 mg 100 g^{-1}), however, 'Sensation' revealed minimum (13.5 mg 100 g^{-1}) contents (Table 3). Statistically substantial ($P \leq 0.05$) differences were also perceived regarding total phenolic contents (TPC) and 'Collector' revealed minimum (15.9 GAE 100 g^{-1}) TPC, while, 'Burma Surkha' exhibited highest (59.1 GAE 100 g^{-1}) TPC in fruit pulp, respectively (Table 3). Total carotenoids (TC) also revealed substantial variations in all mango cultivars and 'Faisalabad Selection' exhibited highest (52.0 µg 100 g^{-1}) TC in pulp of fruit (Table 3). Significant ($P \leq 0.05$) variations were also perceived regarding flavonoids and these varied from 0.42 to 1.79 µg 100 g^{-1}. Maximum flavonoids were found in 'Faisalabad Selection' (1.79 µg 100 g^{-1}), whereas, 'Collector' revealed least flavonoids (0.42 µg 100 g^{-1}), as compared to other varieties (Table 3).

Antioxidants are also very important and play pivotal role against oxidative stress caused by reactive oxygen species, (Jamil et al., 2015) also observed similar results in various indigenous mango genotypes of Pakistan as total antioxidants ranged from 0.7 to 11.5. Moreover, (Tonna et al., 2015) also reported similar trend regarding antioxidants in 'SS-II' (0.40 mM Trolox g^{-1}) and Sindhri (0.97 mM Trolox g^{-1}), respectively. Our findings were contradictory with the results of (Syed, 2009) as he observed ascorbic acid range as 29 to 69.3 mg 100 g^{-1}. The variations in results may be attributed to different production location with genotype potential. TPC are very important for human health and found good proportion of these antioxidants in our selected mango germplasm. Moreover, (Manthey and Veazie, 2009) also found that TPC ranged from 19.5 to 166.7 mg gallic acid equals GAE 100 g^{-1} in 'Tommy Atkins', 'Kent' and 'Haden' cultivars of mango. The differences in results may be accredited to different mango cultivars and production location. Our findings were contrary to the results of (Vazquez-Caicedo et al., 2005) as they found highest β-carotene contents (9.6 mg 100 g^{-1}) in 'Maha Chanok' mango. These variations may be attributed to different climatic conditions as well as based on genetic make-up of various mango cultivars under investigation. In case of flavonoids, our findings were contrary to the results of (Liang-Juan et al., 2011) as they reported flavonoids in the range of 1 to 20 µg 100 g^{-1} in 'Jinhuang', 'Tainong' and 'Xiangya' cultivars. This variation was attributed to different genetic nature of mango cultivars and agro-climatic condition of the region.

Table 4: *Sensory characteristics of indigenous and exotic mango cultivars.*

Cultivars	Taste (Score)	Flavor (Score)	Texture (Score)	Aroma (Score)	Pulp Color (Score)
*Almas	6.66cde	6.16cde	6.00cdef	6.33bc	6.33 bc
**Chaunsa	7.83 ab	8.33 a	7.66 ab	7.00ab	7.66 a
*Collector	6.50 def	6.66bcd	6.66bcd	6.33bc	6.00 cd
**Dusehri	7.66 ab	7.50 ab	8.00 a	7.83 a	7.50 ab
*Early Gold	7.33abcd	6.00cde	6.66bcd	7.16ab	5.66cde
**Faisalabad Selection	8.00 a	7.00 bc	7.00 abc	7.00ab	6.66abc
**Golden Lahotia	7.00bcde	7.00 bc	7.00 abc	7.66abc	6.50abc
**Haider Shah	6.16 ef	6.66bcd	5.83 def	6.33bc	5.66cde
*Kensington Pride	7.00bcde	7.00 bc	6.66 bcd	6.33bc	6.50abc
**Lambay Alfansu	6.16 ef	5.83 de	6.16cdef	6.00bc	4.66 e
*Momi-K	5.16 g	4.66 f	5.33 f	5.33 c	5.66cde
**Saleh Bhai	6.66 cde	5.66def	6.00cdef	7.00ab	5.83cde
**Sanghlakhi	5.00 g	5.50 ef	6.33cdef	6.33bc	5.50cde
*Sensation	5.66 fg	7.00 bc	6.50 cde	6.33bc	6.00 cd
**Sindhri	7.50 abc	7.66 ab	7.66 ab	7.16ab	7.50 ab
**Burma Surkha	8.00 a	7.00 bc	7.00 abc	7.00ab	7.50 ab
**SS-2	4.83 g	5.50 ef	5.50 ef	5.33 c	5.00 de
LSD ($P \leq 0.05$)	1.378	1.205	2.322	1.349	0.922

LSD: *Least significant difference ($P \leq 0.05$); any two means not sharing same letter differ significantly ($P \leq 0.05$), column values sharing similar letters are not different statistically ($P \leq 0.05$).*

Sensory evaluation

Significant differences were found regarding sensory characteristics as 'Faisalabad Selection' and 'Burma Surkha', excelled in sensory evaluation regarding taste, texture, flavour, aroma and pulp color followed by 'Chaunsa', 'Dusehri', 'Sindhri', 'Early Gold' and 'Golden Lahotia' (Table 4). 'Saleh Bhai', 'Lambay Al-

fansu' and 'Collector' exhibited ordinary organoleptic characteristics, however, 'Momi-K', 'Sanglakhi', 'Sensation' and 'SS-II' revealed poor organoleptic characteristics. Based on specific composition of different cultivars, 'Burma Surkha', 'Faisalabad Selection', 'Chaunsa', 'Dusehri', 'Early Gold', 'Golden Lahotia' and' Sindhri' were excelled in sensory evaluation and different cultivars exhibited different score (Table 4).

The variations in sensory properties may be attributed to specific genetic make-up and agro-climatic conditions of Faisalabad region. In sensory evaluation, taste is very critical and it is predominantly due to specific sugar acid ratio based on particular genotype. Moreover, fruit texture is also a key quality parameter in sensory evaluation and plays important role in fruit selection by the consumers (Kudachikar et al., 2001). Flavor is the blend of smell and taste perceptions perceived during eating, whereas, overall flavor imprints is the result of particular taste professed by the taste buds (Kudachikar et al., 2001). In accordance to our findings (Rajwana et al., 2011; Jamil et al., 2015) reported sensory characteristics of different mango cultivars. According to them, sensory/organoleptic traits may be different in different production regions and it is a specific varietal character.

Conclusions

Production potential, fruit physical, biochemical and sensorial characteristics depend on genotype and production locality. The cultivars 'Burma Surkha' and Kensington Pride' exhibited relatively high yield. Moreover, on the basis of physico-chemical and sensory evaluation among the different indigenous cultivars 'Burma Surkha' and 'Faisalabad Selection' emerged as a new promising cultivar with high biochemical, antioxidant and sensory attributes. Among exotic cultivars, 'Kensington Pride' declared as best based on fruit and pulp weight, biochemical as well as antioxidant characteristics and sensory attributes. Conclusively, 'Faisalabad Selection' and 'Burma Surkha' in indigenous and 'Kensington Pride' in exotic cultivars may be cultivated on commercial scale to meet the domestic and International market demand. This manuscript information could be used in breeding and variety improvement program too.

Author's Contribution

Irfan Ali Sabir: Planned and executed the reasech.
Saeed Ahmad: Planned, executed and supervised the reasech.
Muhammad Nafees: Analysis of data, wrote results and discussion.
Ahmad Sattar Khan: Proof reading and editing of the manuscript.
Maryam and Ishtiaq Ahmad: Wote the manuscript.

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