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Fruit Morpho-Physical and Biochemical Characteristics of some Guava (*Psidium guajava* L.) Cultivars and Hybrids Under Subtropical Conditions of Himachal Pradesh

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Abstract: The evaluation of seven guava cultivars and hybrids for cultivation in the subtropical region of Himachal Pradesh as compared to predominantly grown cultivars Allahabad Safeda and Luckhnow-49 was done at RHR&TS, Dhaulakuan (Sirmour, HP) during the years 2016-17 and 2017-18. Fruit size (60.57 x 69.70 mm) and weight (171.71 g) were maximum in Lalit with highest fruit yield (16.45 kg/tree) but lowest yield efficiency (7.43 g/cm^2 TCSA). The fruit shape was ovate with pointed shape at the stalk end in H-1, Shweta and Lucknow-49, whereas others were round in shape. Flesh colour varied from yellow-white to greyed-yellow to orange-white to greyed-red. Maximum TSS (10.98 ºB), total sugars (7.30 %) and reducing sugars (4.84 %) were in Hisar Safeda with minimum acidity (0.19 %). Lucknow-49 has the minimum number of seeds per fruit (123.50). Fruits were soft seeded in Hisar Surkha, whereas, CISH-G-1, Lalit and Allahabada Safeda were medium seeded and the rest were hard seeded. Among nine cultivars and hybrids, Lalit is suitable for table as well as processing purposes whereas among quality characteristics, Hisar Safeda performed better.

Keywords: Guava, Cultivar, Hybrid, Morpho-physical, Biochemical

Guava (*Psidium guajava* L.) is one of the important fruit crops grown in the tropics and subtropics, belonging to the family Myrtaceae. The genus *Psidium* includes some 150 species (Mitra et al 2012). The majority of guava cultivars are diploid (2n=22) that are commercially available (Shukla et al 2012). Guava is rich in vitamin C, carbohydrates, fibres and protein and can be consumed fresh or processed for juice, jam, jelly, cheese, canned segments, nectar, R.T.S, beverages etc. (Pradhan et al 2021). The leaves are used for the treatment of diarrhea as well as for the dyeing and tanning. It has anti-diarrheal, anti-hypertensive, antioxidant, anti-microbial, hypoglycemic and anti-mutagenic activities (Eze et al 2021). Cultivated guava is native to Tropical America, where it occurs wildly. It is known to have been introduced in India as early as the 17th century and at present it is widely cultivated on a commercial scale. Guava occupies an area of 3,08,000 hectares in India resulting in production of 45,82,000 metric tonnes (Anonymous 2021). It is cultivated on an area of 2,320 hectares in Himachal Pradesh with an annual production of 2,610 metric tonnes (Anonymous 2018). It requires 100-200 cm of rainfall per annum with an optimum temperature between 23°C to 26°C.

Guava cultivation is quickly expanding in the country because of its superior adaptability, resistance to diverse biotic and abiotic stresses, and high output combined with minimal input needs. However, to make guava cultivation commercially feasible, it is critical to pick cultivars that are suited to a specific climatic environment based on fruit quality (Singh et al 2013). The lower hills of Himachal Pradesh are seen as suitable for cultivation, especially in the changing climate scenario and producers are seeking for ways to diversify their fruit crops in order to increase their income. The primary commercial cultivars grown for a long period are Allahabad Safeda and Sardar (L-49). The current investigation was conducted to examine the performance of various guava cultivars and hybrids in comparison to these cultivars in the sub-tropical regions of Himachal Pradesh.

MATERIAL AND METHODS

The performance of seven guava cultivars and hybrids viz. H-1, H-2, CISH-G-1, Lalit, CISH-G-4 (Shweta), Hisar Safeda and Hisar Surkha were examined for their fruit and yield characteristics. Allahabad Safeda and Lucknow-49 were used as check varieties that are predominantly grown in the subtropical regions of Himachal Pradesh. The experiment was conducted at Regional Horticultural Research & Training Station, Dhaulakuan (Sirmour, H.P.) during the rainy season located between 35.5 °N latitude and 77.5 °E longitude at an elevation of 468 meters above mean sea level. The plant material for this study consisted of eight-

years-old uniformly growing and bearing trees. Observations were recorded on fruit morpho-physical and biochemical parameters during the rainy season on seven different guava cultivars and hybrids with two check varieties and each having four replications. The experiment was laid out on bearing guava trees in a randomized block design, planted at a distance of 5 x 5 meters. A total of five fruits were selected randomly from all directions from each individual tree and observations so recorded were averaged. Fruit length (mm), fruit width (mm), stalk length (mm), size of sepals (mm), diameter of calyx cavity (mm), core diameter (mm) and thickness of outer flesh in relation to core diameter (mm) were recorded using vernier calipers. Average weight of fruit (g) was measured. The remaining morpho-physical (non-metric) characters were observed as per the UPOV descriptor (Anonymous 1987). Total soluble solids (TSS) content was estimated by using an "Erma–Hand Refractometer" (0 to 32 ºB). The titratable acidity, total, reducing and non-reducing sugars of guava pulp were determined (Ranganna 1995). For seed characters, the fruit pulp was cut into pieces, and boiled for 15 minutes in hot water. Later, the seeds were separated by ordinary sieve (< 20 mm) and the number of seeds was counted. The seed weight per fruit was measured. The size of the seed was measured by taking the length and width of the seed with the use of vernier calipers, and the measurements made were summed. The hardness of the seed was determined by a panel of judges by an organoleptic test and presented as hard, medium and soft. At harvest time, the final fruit yield in different cultivars and hybrids was recorded by weighing the total fruits retained in a particular tree and yield was expressed in kilograms per tree (kg/tree). The yield efficiency of each cultivar and hybrid was calculated according to the Westwood (1978) method and was expressed using the formula g/cm^2 TCSA. The statistical analysis was carried out for each observed character using MS-Excel and OPSTAT (Sheoran et al 1998).

RESULTS AND DISCUSSION

Fruit (morpho-physical) characters: The 2-year pooled data indicates there was significant variation among guava cultivars and hybrids for these traits (Table 1, 2). Lucknow-49 recorded maximum mean fruit length of 71.35 mm which is statistically at par with Allahabad Safeda and CISH-G-4 and the lowest fruit length was in CISH-G-1(48.82 mm). The maximum fruit width (69.70 mm) was in Lalit, followed by Lucknow-49, Hisar Safeda and Allahabad Safeda. Minimum pooled fruit width (57.90 mm) was observed in Hisar Surkha. Deshmukh et al (2013) also observed mean fruit length and width of the different cultivars and hybrids ranging from 59.8 mm to 65.4 mm and 61.5 mm to 69.9 mm, respectively. Similar results were obtained by Dolkar et al (2014), Gupta et al (2016) and Kumari et al (2016). The variation in fruit length and width can be attributed to the genetic constitution of a cultivar (Tiwari et al 2016). There was significant variation in fruit weight between different guava cultivars and hybrids. The maximum weight of the fruit was in Lalit (171.71 g) followed by Lucknow-49. Dolkar et al (2014) reported maximum weight in Lucknow-49 under subtropical conditions. The variation in fruit weight may be due to phenotypic and genotypic influence on different cultivars (Kumari et al 2020). The thickness of the outer flesh ranged from 9.75 mm to 16.88 mm and the core diameter ranged from 46.01 mm to 56.43 mm in all guava cultivars and hybrids. Similar trend was observed by Singh (2013) with 10.17 mm to 17.48 mm and 31.11 mm to 42.35 mm, respectively.

The shape of fruit was pomi (round) and ovate while, fruit shape at stalk end varied from broadly rounded to pointed. The shape at stalk end is rounded in 'Allahabad Safeda' as per PPV&FRA guidelines (Anonymous 2016) which was equivalent to the observations recorded in the present study. Fruit shape in guava has also been described by many workers (Dubey et al 2016; Kumari et al 2016; Ran et al 2017) and similar variations were recorded. There was no significant variation in fruit peel colour, except for slight variations in color shade, but the flesh color varied from yellow-white to greyed-red and several studies conducted also reported such variations (Meena et al 2013, Dubey et al 2016, Kumari et al 2016, Singh et al 2016, Ran et al 2017, Sohi et al 2019). Although flesh colour is a varietal character, slight variation in the intensity may be attributed to the climatic factors and soil type. Relief of the fruit surface was smooth to rough (Table 2). Singh et al (2016) reported rough fruit surfaces in 'CISH-G-1' and 'Lucknow-49'. The longitudinal ridges (present in CISH-G-4, Lucknow-49 and Hisar Safeda) and grooves (present in CISH-G-1, Lalit and Allahabad Safeda) were categorized as present or absent in nine guava cultivars and hybrids. Fruit yield was maximum (16.45 kg/tree) in Lalit and statistically at par with Lucknow-49 and minimum of 12.09 kg/tree was in Hisar Surkha and it was significantly lower than all the other cultivars (Table 1). Meena et al (2013) also reported fruit yields ranging between 5.93 kg/plant to 14.91 kg/plant. Significant variation in yield characters has been observed earlier also (Deshmukh et al 2013, Jana et al 2015, Gupta et al 2016, Kumari et al 2016, Sahoo et al 2017).

Fruit (biochemical) characters: The TSS content in fruits ranged between 9.89 ºB in Allahabad Safeda to 10.98 ºB in Hisar Safeda (Table 1). However, according to Kumari et al (2016), TSS ranged from 9.66 ºB to 11.40 ºB in sub-tropical

Table 1. Fruit morpho-physical and biochemical (metric) characters of some guava cultivars and hybrids

Characters/ Cultivars/ hybrids	Fruit length (mm)	Fruit width (mm)	Weight of fruit (g)	Core diameter (mm)	Thickness of outer flesh in relation to core diameter (mm)	Yield (kg/tree)	Yield efficiency (g/cm^2 TCSA*)	Total Soluble Solids (ºB)	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)	Number of seeds/fruit	Seed weight (g)/fruit	Seed size (mm)
H-1	61.77	58.94	110.75	47.28	10.66	13.18	8.64	10.36	0.28	6.89	4.52	2.26	147.88	5.23	3.82
H-2	49.85	59.96	105.88	46.84	12.63	12.52	9.68	10.64	0.32	7.07	4.73	2.23	217.25	6.30	3.89
CISH-G-1	48.82	60.80	103.29	48.94	10.86	10.98	7.66	10.29	0.22	6.84	4.30	2.42	139.75	3.00	3.36
Lalit (CISH-G-3)	60.57	69.70	171.71	56.43	12.77	16.45	7.43	10.70	0.26	7.12	4.41	2.57	182.75	3.64	3.34
CISH-G-4 (Shweta)	67.51	63.04	139.24	51.79	9.75	13.84	10.41	10.84	0.19	7.21	4.67	2.41	269.75	6.44	3.37
Hisar Safeda	61.59	67.91	157.90	54.68	12.23	14.39	9.41	10.98	0.19	7.30	4.84	2.34	257.50	7.20	4.03
Hisar Surkha	58.69	57.90	105.18	46.01	11.39	12.09	8.14	9.98	0.24	6.63	4.34	2.18	161.25	3.47	3.39
Allahabad Safeda	66.16	67.76	161.91	52.74	14.03	14.77	9.86	9.89	0.29	6.57	4.79	1.70	337.63	11.65	3.50
Lucknow-49 (Sardar)	71.35	68.12	164.44	48.33	16.88	15.48	7.85	10.61	0.24	7.06	4.52	2.41	123.50	2.97	3.48
Mean	60.70	63.79	135.59	50.34	12.36	13.75	8.79	10.48	0.25	6.97	4.57	2.28	204.14	5.55	3.53
CD (p=0.05)	5.74	4.78	29.56	4.69	1.38	1.00	2.87	0.23	0.04	0.19	0.12	0.24	7.96	0.30	0.43

*Trunk Cross Section Area

Table 2. Fruit (morpho-physical) non-metric characters of some guava cultivars and hybrids

Characters/ Cultivars/ hybrids	Fruit shape	Fruit shape at stalk end	Colour of peel	Relief of fruit surface	Ridged collar around calyx cavity	Longitudinal ridges	Prominence of longitudinal ridges	Longitudinal grooves	Colour of flesh	Seed hardness
H-1	Ovate	Pointed	Yellow-Green 145 A	Smooth	Inconspicuous	Absent	-	Absent	Greyed-Red 180 C	Hard
H-2	Pomi (Round)	Broadly Rounded	Yellow-Green 151 A	Rough	Inconspicuous	Absent	-	Absent	Greyed-Red 180 C	Hard
CISH-G-1	Pomi (Round)	Broadly Rounded	Yellow-Green 151 A	Rough	Inconspicuous	Absent	-	Present	Yellow-White 158 A	Medium
Lalit (CISH-G-3)	Pomi (Round)	Broadly Rounded	Yellow-Green 151 A	Rough	Inconspicuous	Absent	-	Present	Greyed-Red 180 C	Medium
CISH-G-4 (Shweta)	Ovate	Pointed	Yellow-Green 151 D & 145 A	Rough	Inconspicuous	Present	Weak	Absent	Greyed-Yellow 160 D	Hard
Hisar Safeda	Pomi (Round)	Rounded	Yellow-Green 153 A & 145 A	Rough	Conspicuous	Present	Weak	Absent	Greyed-Yellow 160 D	Hard
Hisar Surkha	Pomi (Round)	Rounded	Yellow-Green 145 A	Smooth	Inconspicuous	Absent	-	Absent	Greyed-Red 180 B	Soft
Allahabad Safeda	Pomi (Round)	Rounded	Yellow-Green 153 D & 145 A	Smooth	Inconspicuous	Absent	-	Present	Orange-White 159 C & 159 D	Medium
Lucknow-49 (Sardar)	Ovate	Pointed	Yellow-Green 145 A	Rough	Inconspicuous	Present	Medium	Absent	Orange-White 159 C	Hard

condition of Himachal Pradesh. Kumari et al (2020) also reported a minimum TSS in Allahabad Safeda (9.9 ºB). The total sugars ranged from 6.57 per cent to 7.30 per cent, reducing sugars from 4.30 per cent to 4.84 per cent and non-reducing sugars from 1.70 per cent to 2.57 per cent in cultivars and hybrids (Table 1). Similar trend was observed by Kumari et al (2016). The physico-chemical characteristics of guava cultivars and hybrids may vary from place to place depending on climatic factors and management practices. Similar variations for physical and chemical characters like TSS, acidity, sugars were also reported by Ghosh et al (2013), Meena et al (2013), Singh et al (2016), Dubey et al (2016), Gupta et al (2016), Kumari et al (2016) and Bhalekar and Chalak (2017).

Seed characters: Fruit quality in guava also depends upon the seed content of fruit and generally guava contains higher seed content when compared to others. The number of seeds per fruit varied from cultivar to cultivar being maximum (337.63) in Allahabad Safeda with a maximum seed weight (11.65 g) and minimum (123.50) in Lucknow-49 with minimum seed weight (2.97 g) (Table 1). Although variation in the presence of less number of seeds per fruit is a desirable character. Kumari et al (2016) also recorded a low (127) seed number in Lucknow-49 under the sub-tropical conditions of Himachal Pradesh. Seed size for different guava cultivars shows variation in Lalit with a minimum mean of 3.34 mm being statistically equal to CISH-G-1, CISH-G-4, Hisar Surkha, Lucknow-49 and Allahabad Safeda. Maximum seed size was in Hisar Safeda (4.03 mm) which was statistically equal to H-2 and H-1. This trait governs the quality of the fruit in guava, as small seed size is preferred over bold seeds. The fruit was soft seeded in Hisar Surkha, while the medium hard seeded in CISH-G-1, Lalit and Allahabad Safeda and the rest were hard seeded. The present findings are in accordance with the findings of Kumari et al (2016); Bhalekar and Chalak (2017) where seed texture of guava was in the range of soft, medium and hard.

CONCLUSION

The maximum fruit size, weight and yield were observed in Lalit with medium seed hardness and greyed red flesh colour while total soluble solids and reducing sugars were maximum in Hisar Safeda with minimum acidity. So, other than Allahabad Safeda and Lucknow-49, these two varieties (Lalit and Hisar Safeda) can also be used for commercial cultivation in the subtropical regions of Himachal Pradesh to get better returns.

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