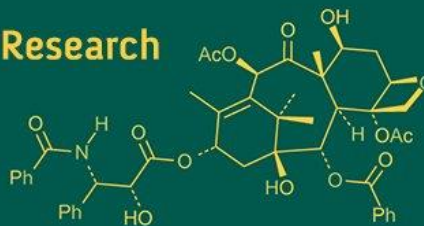


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Assessment of morphological and biochemical diversity in guava genotypes

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Abstract

The present investigation entitled “Assessment of Morphological and Biochemical Diversity in Guava Genotypes” was conducted to evaluate the variability among nine guava genotypes for important physical and biochemical fruit quality traits under agro-climatic conditions of Banda, Uttar Pradesh. Seven varieties namely Allahabad Safeda (T₁), L-49 (T₂), Shweta (T₃), Lalit (T₄), VNR Bihi (T₅), Chittidar (T₆), and Thai Pink (T₇) were grown at Banda University of Agriculture and Technology, Banda, while T₈ and T₉ were the two farmer selections from Jhansi and Chitrakoot, respectively. Variability was found in genotypes in respect of all physical and biochemical traits. Among physical parameters, Allahabad Safeda was found to have maximum weight of fruit (245.33 g), fruit volume (237.33 cm³), pulp weight (204.00 g), and flesh thickness (2.50 cm). On the other hand, Chittidar had the highest number of seeds per fruit (324.33). Minimum seed number per fruit was found in Thai pink with value 144.33, while its antioxidant activity was the highest with a value of 2885.79 µmol TE/100 g. Chitrakoot local selection was found to have maximum total sugar content (12.13 g/100 g), while maximum total soluble solids was seen in Chittidar (13.13 °Brix). Shweta had the maximum pectin content (7.94 g/100 g) and maximum phenol content.

Keywords: Guava, genetic variability, biochemical traits, fruit quality and germplasm

Introduction

Guava (*Psidium guajava* L.) is one of the most important fruit crops of tropical and subtropical regions and belongs to the family Myrtaceae. It is commonly referred to as the “Apple of the Tropics” because of its high nutritive value, pleasant flavor, excellent taste, and wider adaptability under diverse agro-climatic conditions. Guava is native to tropical America and has become extensively cultivated in many countries including India, Brazil, Mexico, Thailand, Pakistan, and Bangladesh. Guava enjoys a distinguished status amongst other fruit crops in India owing to its high yield capacity, regular bearing ability, and adaptability under marginal and semi-arid environments. India ranks first amongst countries that produce guava, accounting for a significant proportion of guava production globally. Guava is grown extensively in many states including Uttar Pradesh, Bihar, Madhya Pradesh, Maharashtra, Karnataka, and Andhra Pradesh. Uttar Pradesh alone produces a considerable portion of guava fruits produced in the country due to favourable climatic conditions and improved cultivars. Guava fruits have received much admiration and popularity because of their high value both as a fresh fruit and for processing purposes, such as guava jelly, nectar, jam, puree, squash, candy, and dried fruits. Guava fruits are regarded as nutritious fruits because of their richness in vitamin C, sugars, minerals, antioxidants, phenols, dietary fibre, and pectin. The fruit is rich in several bioactive compounds that provide antioxidative, antimicrobial, anti-inflammatory, and anti-diabetic effects. Owing to the presence of high antioxidative and vitamin C compounds in the fruit, guava has gained much recognition and appreciation for its nutraceutical properties and is viewed as a functional food crop. The nutritional profile of the fruit differs greatly amongst genotypes based. Among all factors, genetic diversity is considered to be an important prerequisite for breeding crop improvement programs. Genetic evaluation and characterization of germplasm are extremely informative concerning the level of genetic variability of the studied species.

The morphological and biochemical characterization of guava germplasm is very important for the selection of superior genotypes having good attributes concerning fruit quality like large fruit size, more pulp percentage, fewer seeds, good taste, high vitamin C, antioxidant potential, and suitability for processing. The morphological traits are commonly used for the initial estimation of genetic diversity due to their simplicity, economy, and association with commercial value. Fruits size, weight, flesh thickness, pulp percent, and seed attributes are very important economic characters, affecting marketing and consumer choice. Likewise, biochemical parameters like total soluble solids, acidity, sugar, ascorbic acid, polyphenols, fiber, pectin, and antioxidant activity are very important for the quality and nutritive value of the fruits. Many researchers have found significant variability for various physical and biochemical traits in guava cultivars. For instance, genetic diversity among guava genotypes was estimated by Singh *et al.*, (2015) ^[17]. Gangappa *et al.* (2022) ^[2] stressed the value of morpho-biochemical characterization for identifying better guava germplasm with improved nutritional quality. Nikhil *et al.* (2021) ^[12] reported notable variability among guava hybrids and genotypes regarding fruit quality traits and recommended using them in future breeding programs. Likewise, Mishra *et al.* (2026) ^[11] pointed out how morpho-biochemical characterization can help in effectively using globally collected guava germplasm. The Bundelkhand region of Uttar Pradesh has suitable climate and soil for growing guava. However, there is limited research on the available guava varieties in this area. This study, titled “Assessment of Morphological and Biochemical Diversity in Guava Genotypes,” aims to evaluate the differences among chosen guava cultivars and local farmer selections. It focuses on key physical and biochemical fruit quality factors in the conditions of Banda, Uttar Pradesh.

Materials and Methods

The present investigation entitled “Assessment of Morphological and Biochemical Diversity in Guava Genotypes” was conducted at the experimental orchard of Banda University of Agriculture and Technology, Banda, Uttar Pradesh during the fruiting season. Banda is located in the Bundelkhand region of Uttar Pradesh. It has a semi-arid subtropical climate, with hot summers, moderate winters, and low annual rainfall. The experimental site has sandy loam soil that is moderately fertile and provides good drainage, making it suitable for guava cultivation. The experiment included nine guava genotypes, consisting of seven established cultivars and two selected by local farmers. The cultivars were Allahabad Safeda (T₁), L-49 (T₂), Shweta (T₃), Lalit (T₄), VNR Bihi (T₅), Chittidar (T₆), and Thai Pink (T₇). These were grown at Banda University of Agriculture and Technology. T₈ and T₉ included local farmer selections from Jhansi and Chitrakoot districts, respectively. Healthy, uniform trees that regularly bear fruit were chosen for recording observations. During the peak harvesting period, all the selected genotypes were harvested manually for fully matured and physiologically ripe fruits. Fruits free from insect infestation, disease and mechanical injury were selected for analysis. Physical and biochemical parameters were recorded on randomly selected fruits of each genotype. Observations on physical parameters were recorded using standard procedures. Fruit length and fruit diameter were measured in centimeters using a digital

Vernier caliper. Fruit weight was recorded in grams using a precision electronic balance. Fruit volume was determined by the water displacement method and expressed in cubic centimeters. Specific gravity was calculated as the ratio of fruit weight to fruit volume. Flesh thickness and seed cavity size were measured with the help of a Vernier caliper after cutting the fruits transversely into two equal halves. Pulp weight and seed cavity weight were recorded separately using an electronic balance after carefully separating the edible pulp portion and seed cavity tissues. The number of seeds per fruit was counted manually and expressed as the average number of seeds per fruit.

Biochemical parameters were analyzed using standard laboratory procedures. Total soluble solids (TSS) were measured with the help of a hand refractometer and expressed in °Brix after proper temperature correction. Titratable acidity was determined by titrating the fruit juice against standard sodium hydroxide solution using phenolphthalein as an indicator and expressed as percent citric acid. Reducing sugar and non-reducing sugar contents were estimated following standard analytical methods, and total sugar was calculated accordingly. Ascorbic acid content was estimated by the dye titration method using 2,6-dichlorophenol indophenol dye and expressed as mg per 100 g pulp. Total phenol content was estimated by standard spectrophotometric procedures and expressed as mg per 100 g pulp. Antioxidant activity was measured and expressed as µmol TE per 100 g pulp. Fibre content was determined following standard gravimetric procedures and expressed as g per 100 g pulp. Pectin content was estimated using standard extraction and precipitation methods and expressed as g per 100 g pulp. The data recorded for various physical and biochemical traits were statistically analyzed by adopting standard procedures of analysis of variance (ANOVA). The significance of differences among treatment means was tested using standard error of mean (SEm±) and critical difference (CD) at 5 percent level of significance.



Chittidar



L-49



VNR Bihi



Allahabad Safeda



Shweta

Results and Discussion

The results obtained from the present investigation clearly indicated the existence of substantial morphological and biochemical variability among the evaluated guava genotypes. Significant differences were observed for all physical and biochemical traits, suggesting the presence of considerable genetic diversity which can be effectively utilized in future breeding and varietal improvement programmes. The variability among genotypes may be attributed to differences in their genetic constitution, adaptation to environmental conditions, and physiological efficiency in assimilate partitioning.

Physical Characteristics of Fruits

Fruit Length and Fruit Diameter

Fruit length and fruit diameter are important physical parameters directly associated with market preference and consumer acceptance. The data presented in Table 1 revealed significant variation among the guava genotypes for these traits. Fruit length varied from 6.90 cm to 8.67 cm. The maximum fruit length was recorded in Allahabad Safeda (8.67 cm), followed by the Chitrakoot local selection (8.40 cm) and L-49 (8.17 cm), whereas the minimum fruit length was observed in VNR Bihi (6.90 cm). Similarly, fruit

diameter ranged from 6.70 cm to 8.27 cm. Allahabad Safeda exhibited the maximum fruit diameter (8.27 cm), followed by Chitrakoot local selection (8.00 cm) and L-49 (7.90 cm), while the minimum diameter was recorded in VNR Bihi (6.70 cm). The superiority of Allahabad Safeda for fruit dimensions may be due to its better genetic potential and efficient translocation of photosynthates toward developing fruits. Larger fruit size is considered an economically desirable trait because it enhances consumer appeal and market value. Similar variability in fruit size among guava genotypes was reported by Singh *et al.* (2015) ^[17], Kumar and Tiwari (2017) ^[9], and Gangappa *et al.* (2022) ^[2], who observed substantial differences among guava cultivars for fruit dimensions. The observed differences among the genotypes may also be influenced by cell enlargement, moisture retention capacity, and varietal differences in fruit growth pattern. High variability in fruit dimensions among guava germplasm has also been documented by Patel *et al.* (2018) ^[19], indicating the importance of fruit size as a reliable selection criterion in guava improvement programmes.

Fruit Weight and Fruit Volume

Fruit weight is one of the most important yield-contributing and commercial quality parameters in guava. Significant differences were observed among the genotypes for fruit weight. The highest fruit weight was recorded in Allahabad Safeda (245.33 g), followed by Chitrakoot local selection (222.67 g) and L-49 (227.00 g). The lowest fruit weight was observed in VNR Bihi (151.67 g). Fruit volume also varied significantly among the genotypes and ranged from 147.33 cm³ in VNR Bihi to 237.33 cm³ in Allahabad Safeda. Genotypes with larger fruit dimensions generally exhibited higher fruit volume and fruit weight. The larger fruit volume in Allahabad Safeda may be attributed to higher pulp accumulation and enhanced cellular expansion during fruit development. Fruit weight and fruit volume are strongly influenced by genotype, nutrient uptake efficiency, environmental adaptation, and hormonal regulation during fruit development. Similar findings were reported by Rajan *et al.* (2016) ^[15], who observed significant variability in fruit weight among guava cultivars. Singh and Sharma (2019) ^[18] also reported that genotypes possessing larger fruit size and greater pulp accumulation are preferred for commercial cultivation and processing purposes. Higher fruit weight is generally associated with increased edible portion and better economic returns to growers. Therefore, Allahabad Safeda, L-49, and Chitrakoot local selection may be considered promising genotypes for commercial cultivation under Bundelkhand conditions.

Specific Gravity and Flesh Thickness

Specific gravity is an important indicator of fruit compactness and tissue density. In the present investigation, specific gravity ranged from 1.02 to 1.04. The Jhansi local selection recorded the highest specific gravity (1.04), while most of the remaining genotypes exhibited values between 1.02 and 1.03. Flesh thickness varied significantly among the genotypes and ranged from 1.83 cm to 2.50 cm. Allahabad Safeda recorded the highest flesh thickness (2.50 cm), followed by Chitrakoot local selection (2.37 cm) and L-49 (2.30 cm), whereas the lowest value was recorded in VNR Bihi (1.83 cm). Flesh thickness is an important quality parameter because it determines the edible portion of the

fruit and influences consumer acceptance. Genotypes with higher flesh thickness generally possess higher pulp content and better processing potential. Similar observations were reported by Shukla *et al.* (2018) ^[16], who observed considerable variability in flesh thickness among guava cultivars. The higher flesh thickness observed in Allahabad Safeda may be due to enhanced development of mesocarp tissues and greater accumulation of carbohydrates in fruit pulp. These findings are in agreement with those reported by Mishra *et al.* (2026) ^[11], who highlighted the significance of flesh thickness as a desirable trait for fresh market and processing industries.

Seed Cavity Size, Pulp Weight and Seed Cavity Weight

Seed cavity size ranged from 2.47 cm to 3.10 cm. Allahabad Safeda recorded the maximum seed cavity size (3.10 cm), while VNR Bihi exhibited the minimum value (2.47 cm). Variability in seed cavity size among genotypes may be due to genetic differences affecting fruit anatomy and internal tissue development. Pulp weight showed remarkable variation among the genotypes and ranged from 123.67 g to 204.00 g. Allahabad Safeda produced the maximum pulp weight (204.00 g), followed by Chitrakoot local selection (188.67 g) and L-49 (187.00 g). The minimum pulp weight was recorded in VNR Bihi. Higher pulp weight is considered highly desirable because it increases the edible portion and enhances suitability for processing industries. The superior pulp weight observed in Allahabad Safeda may be attributed to higher flesh thickness and better assimilate accumulation in fruit tissues. Seed cavity weight ranged from 18.33 g to 30.00 g. The highest seed cavity weight was recorded in L-49 (30.00 g), whereas Thai Pink exhibited the lowest value (18.33 g). The observed variation in pulp and seed cavity characteristics among guava genotypes corroborates the findings of Singh *et al.* (2020) ^[20], who reported significant diversity among guava cultivars for pulp percentage and internal fruit quality.

Number of Seeds per Fruit

The number of seeds per fruit is an important trait influencing consumer preference and processing quality. Significant variability was observed among the evaluated genotypes. Chittidar recorded the highest number of seeds per fruit (324.33), while Thai Pink exhibited the minimum seed number (144.33). Lower seed number is considered a highly desirable character in guava because it improves eating quality and consumer acceptability. The lower seed content observed in Thai Pink may be attributed to varietal characteristics and reduced seed development. Similar findings were reported by Kher *et al.* (2015) ^[8], who emphasized the importance of low seed content in selecting superior guava cultivars. The higher seed number observed in Chittidar may reduce consumer preference for fresh consumption; however, the genotype may still be useful for breeding purposes owing to its superior biochemical characteristics.

Biochemical Characteristics of Fruits

Total Soluble Solids (TSS)

Total soluble solids are considered one of the most important indicators of fruit sweetness and eating quality. Significant differences were observed among the genotypes for TSS content. TSS values ranged from 11.01 °Brix in VNR Bihi to 13.13 °Brix in Chittidar. Chittidar recorded the

maximum TSS (13.13 °Brix), closely followed by Shweta (13.07 °Brix) and Allahabad Safeda (13.04 °Brix). The higher TSS content observed in these genotypes may be attributed to enhanced conversion of starch into soluble sugars during fruit ripening. Higher TSS is desirable for both fresh consumption and processing purposes because it contributes to improved sweetness, flavor, and overall fruit quality. Similar variability in TSS among guava genotypes has been reported by Nikhil *et al.* (2021) ^[12], Singh *et al.* (2017) ^[19], and Kumar *et al.* (2020) ^[10]. Environmental factors, varietal characteristics, and maturity stage of fruits also influence TSS accumulation. The superior TSS content observed in Chittidar and Shweta suggests their suitability for fresh consumption and processing industries.

Titrateable Acidity

Titrateable acidity significantly influences fruit flavor and taste balance. In the present study, acidity ranged from 0.30% to 0.62%. Thai Pink recorded the minimum acidity (0.30%), followed by Shweta and VNR Bihi (0.34%), whereas the Chitrakoot local selection exhibited the highest acidity (0.62%). Lower acidity combined with higher sugar content improves palatability and consumer acceptance. The low acidity observed in Thai Pink may contribute to its sweeter taste and better eating quality. Similar findings were reported by Patel and Singh (2018) ^[19], who observed significant variability in acidity among guava cultivars. The variation in acidity may be associated with differences in organic acid metabolism and conversion of acids into sugars during ripening.

Reducing Sugar, Non-Reducing Sugar and Total Sugar

Sugars are major constituents determining fruit sweetness and flavor. Significant variation was observed among the genotypes for reducing sugar, non-reducing sugar, and total sugar content.

Reducing sugar ranged from 5.06 g/100 g in VNR Bihi to 6.90 g/100 g in Chitrakoot local selection. Non-reducing sugar varied between 3.08 g/100 g and 5.11 g/100 g, with the highest value recorded in Chitrakoot local selection. Total sugar content ranged from 8.82 g/100 g to 12.13 g/100 g. Chitrakoot local selection recorded the highest total sugar content (12.13 g/100 g), followed by Allahabad Safeda (11.20 g/100 g). The lowest total sugar was observed in VNR Bihi. The higher sugar accumulation in Chitrakoot local selection may be due to increased photosynthetic efficiency and efficient translocation of carbohydrates toward fruit tissues. Similar findings were reported by Jha *et al.* (2019) ^[4], who observed substantial variation in sugar content among guava cultivars. The balance between sugars and acidity plays a major role in determining fruit flavor and processing quality. Therefore, genotypes possessing higher sugar content and moderate acidity are considered desirable.

Ascorbic Acid Content

Guava is widely recognized as one of the richest natural sources of vitamin C. Significant variation was observed among the genotypes for ascorbic acid content. The values ranged from 128.34 mg/100 g in VNR Bihi to 260.40 mg/100 g in Allahabad Safeda. Allahabad Safeda recorded the highest ascorbic acid content (260.40 mg/100 g), closely followed by Thai Pink (259.41 mg/100 g). The higher vitamin C content observed in these genotypes indicates their superior nutritional quality. Ascorbic acid plays an

important role as a natural antioxidant and contributes significantly to human health by enhancing immunity and reducing oxidative stress. Similar findings regarding variability in vitamin C content among guava cultivars were reported by Thaipong *et al.* (2006) ^[21], Singh *et al.* (2015) ^[17], and Gangappa *et al.* (2022) ^[2]. The observed differences among genotypes may be due to genetic factors regulating biosynthesis and accumulation of ascorbic acid during fruit development.

Phenol Content and Antioxidant Activity

Phenolic compounds are important bioactive constituents responsible for antioxidant properties in fruits. Significant differences were observed among the guava genotypes for phenol content and antioxidant activity. Phenol content ranged from 146.51 mg/100 g in VNR Bihi to 302.50 mg/100 g in Thai Pink. Similarly, antioxidant activity varied from 1545.98 µmol TE/100 g to 2885.79 µmol TE/100 g. Thai Pink recorded the highest phenol content as well as maximum antioxidant activity. The higher antioxidant potential of Thai Pink may be attributed to increased accumulation of phenolic compounds and other antioxidant metabolites. Antioxidants play an important role in neutralizing free radicals and reducing oxidative damage in human cells. Therefore, genotypes with higher antioxidant activity possess greater nutraceutical and therapeutic value. Similar findings were reported by Thaipong *et al.* (2006) ^[21],

Jiménez-Escrig *et al.* (2001) ^[5], and Vishwakarma *et al.* (2023) ^[22]. The superior antioxidant activity observed in Thai Pink suggests its potential utility in functional food industries and health-oriented breeding programmes.

Fibre and Pectin Content

Dietary fibre and pectin are important quality parameters associated with digestive health and processing suitability. Significant differences were observed among the genotypes for fibre and pectin content. Fibre content ranged from 2.43 g/100 g in Shweta to 5.01 g/100 g in Thai Pink. Higher fibre content is considered beneficial for human health because it improves digestion and reduces the risk of several metabolic disorders.

Pectin content varied considerably among the genotypes and ranged from 1.26 g/100 g to 7.94 g/100 g. Shweta recorded exceptionally high pectin content (7.94 g/100 g), while Jhansi local selection recorded the minimum value. Pectin is an important polysaccharide used extensively in jelly and jam preparation. Therefore, genotypes with higher pectin content are highly desirable for processing industries. Similar findings regarding variability in pectin content among guava cultivars were reported by Joseph and Priya (2011) ^[6] and Kaur *et al.* (2019) ^[7]. The higher pectin content observed in Shweta indicates its suitability for processing purposes and value-added product preparation.

Table 1: Physical parameters of guava genotypes

Variety	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruit volume	Specific gravity	Flesh thickness (cm)	Seed cavity size (cm)	Pulp weight (g)	Seed cavity weight (g)	Number of seeds
T ₁	8.67	8.27	245.33	237.33	1.03	2.50	3.10	204.00	28.00	266.33
T ₂	8.17	7.90	227.00	219.33	1.02	2.30	3.00	187.00	30.00	243.67
T ₃	7.90	7.60	204.00	198.00	1.03	2.17	2.77	169.00	23.67	209.67
T ₄	7.50	7.20	188.33	182.33	1.02	2.03	2.67	155.67	21.67	184.33
T ₅	6.90	6.70	151.67	147.33	1.03	1.83	2.47	123.67	19.67	164.33
T ₆	7.30	7.00	175.33	170.00	1.03	1.87	2.87	139.33	26.67	324.33
T ₇	8.10	7.80	213.67	207.33	1.02	2.27	2.57	183.33	18.33	144.33
T ₈	7.80	7.50	200.67	194.00	1.04	2.17	2.67	167.67	22.67	197.00
T ₉	8.40	8.00	222.67	215.33	1.03	2.37	2.87	188.67	24.67	226.67
SE±	0.01	0.01	0.50	0.40	0.01	0.02	0.01	0.54	0.18	0.58
CD at 5%	0.04	0.03	1.49	1.21	0.03	0.06	0.04	1.63	0.53	1.75

Table 2: Biochemical parameters of guava genotypes

Variety	TSS (°Brix)	Acidity (%)	Reducing sugar	Non-reducing sugar	Total sugar	Ascorbic acid	Phenol	Antioxidant	Fibre	Pectin
T ₁	13.04	0.50	6.84	3.88	11.20	260.40	198.00	1951.53	3.85	2.10
T ₂	12.09	0.49	5.93	4.09	9.92	219.38	197.88	2209.21	4.02	1.79
T ₃	13.07	0.34	5.58	3.55	9.07	169.50	228.85	2556.71	2.43	1.94
T ₄	11.88	0.40	6.08	3.95	9.95	242.52	189.53	1906.51	2.85	1.52
T ₅	11.01	0.34	5.06	3.08	8.82	128.34	146.51	1545.98	3.54	2.18
T ₆	13.13	0.41	6.44	4.30	10.06	155.68	210.26	2314.44	3.92	1.47
T ₇	12.65	0.30	5.08	3.76	8.97	259.41	302.50	2885.79	5.01	2.56
T ₈	12.95	0.56	6.02	4.45	10.15	180.96	177.09	2122.22	3.14	1.26
T ₉	12.03	0.62	6.90	5.11	12.13	235.62	157.54	1604.69	4.11	1.78
SE±	0.15	0.01	0.06	0.07	0.12	2.48	3.06	30.12	0.07	0.04
CD at 5%	0.46	0.02	0.17	0.21	0.35	7.44	9.17	90.30	0.20	0.12

Conclusion

The present investigation revealed considerable morphological and biochemical variability among the evaluated guava genotypes. Allahabad Safeda emerged as a superior genotype for physical fruit quality traits such as fruit size, fruit weight, flesh thickness, and pulp weight. Chittidar recorded the highest TSS, whereas Thai Pink exhibited minimum seed number along with superior

antioxidant and phenol content. The Chitrakoot local selection showed higher sugar accumulation, while Shweta possessed exceptionally high pectin content.

The observed variability among genotypes provides ample scope for selection and utilization of promising cultivars in breeding programmes aimed at improving fruit quality, nutritional composition, and processing suitability in guava. The identified superior genotypes may also be

recommended for commercial cultivation under Bundelkhand conditions.

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