**Biochemical characterization of thirty genotypes of banana (*Musa* spp.)**

**ABSTRACT**

 The present investigation entitled “Biochemical characterization of thirty genotypes of banana (*Musa* spp.)” was conducted at the fruit Research Station (FRS), Gandevi, Navsari Agricultural University, during 2021-22. Fruit biochemical parameters were analyzed at the department of Post-Harvest Technology, ASPEE College of Horticulture, Navsari Agricultural University, Navsari. The fruit biochemical profiling revealed notable variations in key quality-related parameters, including Total Soluble Solids (TSS), sugar composition, titratable acidity, ascorbic acid concentration, total phenolic content, fruit firmness, and pH levels. Chandra Balae (AAA genome group) recorded the highest TSS (27.60°Brix), while Karpura Chakkakeli (AAB genome group) had the highest total sugar content (22.17%). The highest ascorbic acid content was found in Poovan (10.75 mg/100 g, AAB genome group), while Saba (ABB genome group) recorded highest fruit firmness (6.45). These biochemical traits are key indicators of fruit quality, influencing consumer preference, marketability, shelf life, and suitability for processing.

**Key words:** Banana, Biochemical, TSS, PH, Total sugars

**Introduction:**

Banana is a large herbaceous perennial monocotyledonous plant in the order Zingerberales (Simmonds, 1959). It is known as the “Apple of Paradise” and has originated from the tropical region of South-East Asia. The banana crop has nutritional, medicinal and industrial value and it is known for its antiquity. It is deeply interwoven with Indian heritage, religion and culture. Owing to its socio-economic significance and multifaceted uses, it is referred to as ‘*Kalpataru*’ (plant of virtues). Botanically, the banana fruit is a wonder berry, which forms the staple food of millions of people across the globe, providing a more balanced food than any other fruit. It is a viable source of income for the farmers in their respective growing regions (Singh, 2002). Banana (*Musa* spp.) is one of the major fruit crops in the tropical and subtropical region and makes a vital contribution to the economics of a number of countries. It is very important in the nutrition of the local population as well as tradable commodities with a large market throughout the developed world. Banana is commercially the fourth most important global food commodity after paddy, wheat and milk in terms of gross value of production and of great socio- economic significance. In India, banana ranks first in production and productivity among all fruits (Deshmukh et al., 2009). It ranks second in the area after mango. However, Andhra Pradesh, Maharashtra, Gujarat, Tamil Nadu, Karnataka, Uttar Pradesh, Bihar, West Bengal and some parts of the North Eastern region have ideal conditions for its growth and production. In India, it is cultivated over an estimated area of 9.47 lakh hectares and accounts for 13.63 per cent of the total fruit area. The annual production is 377.66 lakh MT. Banana has a 32.71 per cent share in fruit production and productivity of 39.87 MT/ha (Anon., 2025). In Gujarat, it is cultivated over an estimated area of 0.596 lakh hectares, with a production of about 40.10 lakh MT and productivity of 67.28 MT/ha (Anon., 2025). It is one of the most important fruit crops in the Middle and South Gujarat region. In Gujarat, Narmada, Bharuch, Anand, Vadodara, Surat, Chhota Udepur and Navsari are the leading districts in banana production because of favorable agro-climatic conditions and an abundant supply of irrigation water. Farmers prefer its cultivation because of its high demand and net return in the market.

**Materials and methods:**

The present investigation entitled “Biochemical characterization of thirty genotypes of banana (*Musa* spp.)” was conducted at the Fruit Research Station (FRS), Navsari Agricultural University, Gandevi, during 2021-22. Fruit biochemical parameters were analyzed at the Department of Post-Harvest Technology, ASPEE College of Horticulture, Navsari Agricultural University, Navsari.

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| **Table 1: Details of banana genotypes evaluated** |
| **Treatments** | **Genotypes** | **Genome** | **Treatments** | **Genotypes** | **Genome** |
| T1 | Elavazhai | BB | T16 | Vadakkan Kadali | AA |
| T2 | Aktoman | AB | T17 | Matti | AA |
| T3 | Kunnan | AB | T18 | Chetty | AB |
| T4 | Kali | AB | T19 | Valiyakunnan | AB |
| T5 | Hannuman | AAA | T20 | Chandra Balae | AAA |
| T6 | Mahalaxmi | AAA | T21 | Lalkel | AAA |
| T7 | Cv. Rose | AAB | T22 | Basrai | AAA |
| T8 | Raja Balae | AAB | T23 | Jahaji | AAA |
| T9 | Poovan | AAB | T24 | Karpura Chakkakeli | AAB |
| T10 | Rajapuri | AAB | T25 | Parakuni | AAB |
| T11 | Hybrid-1 | AAB | T26 | Monthan | ABB |
| T12 | Alpan | AAB | T27 | Saba | ABB |
| T13 | Ladan | AAB | T28 | NRCB -10 | ABB |
| T14 | Grand Naine (C) | AAA | T29 | Peyan | ABB |
| T15 | Gandevi Selection (C) | AAA | T30 | Udhyam | ABB |

**TSS**: Total soluble solids (TSS) of the fruit pulp were recorded by using digital hand refractometer (Range of 0 to 32 °Brix). Refractometer prism and readings were recorded and expressed in ºBrix

**Reducing sugars (%)**: The pulp of 25 g was taken in a volumetric flask and 2 ml of 45 % basic lead acetate solution was added for clarification. After 10 minutes, the solution was retained by adding potassium oxalate crystals in excess and the volume was made up to a known amount of 250 ml with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was taken in a burette and titrated against boiling Fehling’s mixture (5 ml of Fehling’s solution A + 5 ml of Fehling’s solution B) till the blue color arrived. Then 1 ml of methylene blue indicator (1%) was added and the titration was continued till the contents attained a brick red color and titre value was recorded. The percentage of reducing sugars was calculated according to the following formula:

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| Reducing sugars (%) = | Glucose eq. (0.05) x Total volume made up (ml) | x 100 |
| Titrate value (ml) x Weight of the pulp (g) |
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**Total sugars (%):** For total sugar estimation, the filtrate obtained in the above estimation was used. An aliquot of 100 ml was taken from the filtrate and to one fifth of its volume of hydrochloric acid (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 per cent sodium hydroxide using phenolphthalein as an indicator. The solution was filtered. It was taken up in to the burette and titration was carried out using filtrate as described for reducing sugars. The total sugars content was calculated according to the following formula and expressed in percentage:

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| **Total sugars (%) =** | Glucose eq. of Fehling (0.05) x Total volume made up (ml) x Volume made up after inversion | x100 |
| Titrate value(ml) x Weight of the pulp (g) x Aliquot taken for inversion |

**Non Reducing sugars (%)**: Non-reducing sugars percentage was calculated by subtracting the reducing sugars (%) from the total sugars (%).

 **pH:** To measure pH, the pH electrode is first calibrated with standard buffer solutions with known pH values that span the range being measured. To make a pH measurement, the electrode is immersed into the fruit pulp sample until a steady reading is reached

**Ascorbic acid (mg/ 100 g):** The vitamin C, ascorbic acid content was determined by the Dye method as detailed by Ranganna (1986). The 5 g weighed sample (banana pulp) was taken and transferred in 100 ml volumetric flask. The volume was made up with 4 % oxalic acid solution. After 30 minutes, the suspension was filtered through Whatman No. 1 filter paper. Before titration 2, 6- dichlorophenol indophenols (Dye solution) were standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. 5 ml of the aliquot was taken from the filtrate and titrated against dye solution through a burette till a pink colour persisted for a few seconds. Ascorbic acid content was expressed as mg of ascorbic acid per 100 g sample

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| **Ascorbic acid (mg/100 g) =** | Titrate value (ml) x Dye value x Volume made up (ml) | x 100 |
| Aliquot taken for estimation x Weight of volume of sample taken for estimation (ml) |

**Acidity (%):** Titratable acidity was determined by direct titration of diluted pulp with 0.1N NaOH using phenolphthalein as indicator and expressed as percentage of citric acid (Ranganna, 1986).After digestion samples were filtered and washed of the residues to remove excess alkali. Filtrate was dried at 130°C for one hour and weighed.

**Phenols (mg/100 g):** Total phenols were measured as an index of antioxidants. The total phenols extracted in 10-15 times the volume of 80 percent ethanol were estimated based on their reaction with an oxidizing agent phosphomolybdate in Folin-Ciocalteau reagent under alkaline conditions in a boiling water bath for one minute. The developed blue color was measured at 650 mm in a colorimeter (Sadasivam and Manickam, 1996). The standard curve was prepared using different concentrations (20-100 g/ml) of catechol; the results were expressed as mg per 100 g on fresh weight basis.

**Fruit Firmness (kg/cm2):** A fruit's firmness is its crispness. It can be measured by applying pressure. A penetrometer is a tool that measures the force needed to puncture a fruit's flesh until it's irreversibly damaged. The pressure is measured in pounds and kilograms of force.

 **Result and discussion:**

The result from Table-2 revealed that the highest TSS value was recorded in Chandra Balae (27.60 °B), followed by Matti (26.58 °B) and Hannuman (26.33°B) indicating their superior sweetness and potential preference for fresh consumption. Several genotypes, including Raja Balae (25.22 °B), Rajapuri (25.53 °B), Hybrid-1 (25.48 °B) and Karpura Chakkakeli (25.49 °B), also exhibited high TSS, making them favourable for dessert purposes. Similar findings were obtained by Parmar and Mor (2018) and Jena *et al.* (2020). The total sugar content (22.17 %) was significantly higher in T24: Karpura Chakkakeli, which was at par with T18: Chetty (20.28 %). In T24: Karpura Chakkakeli found that reducing sugar content (17.67 %) was significantly higher. Maximum non-reducing sugar content was recorded in Saba (6.93 %) followed by Peyan (6.73 %) and Lalkel (6.29 %) indicating their potential for enhanced sweetness and suitability for fresh consumption. This is in agreement with the findings of Ara et al. (2012); Parmar and Mor (2018) and Jena *et al*. (2020). pH in banana genotypes were statistically analyzed and detailed in table and it was found that pH (5.35) was significantly highest in T27: Saba. While the lowest pH (4.03) was recorded in T1: Elavazhai. The pH variations were associated with both TA contents and the genetic makeup of a particular cultivar. A similar pH variation for dessert banana cultivars was reported by Newilah *et al.* (2009).

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| **Table-2: Evaluation of banana genotypes with respect to TSS, Total sugars, Reducing sugars, Non-reducing sugars and pH.** |
| **Treatments** | **TSS (ᵒB)** | **TS (%)** | **RS (%)** | **NRS (%)** | **pH** |
| T1 | Elavazhai | 21.65 | 14.11 | 11.44 | 2.67 | 4.03 |
| T2 | Aktoman | 22.65d | 13.89 | 9.05 | 4.84d | 5.03abcd |
| T3 | Kunnan | 24.23bc | 15.87 | 11.39 | 4.48 | 4.85abcd |
| T4 | Kali | 21.85 | 14.80 | 9.93 | 4.88d | 4.72bcd |
| T5 | Hannuman | 26.33ab | 14.46 | 9.23 | 5.23cd | 4.38 |
| T6 | Mahalaxmi | 24.21bcd | 15.21 | 12.17 | 3.04 | 4.78abcd |
| T7 | Cv. Rose | 21.73 | 14.97 | 11.91 | 3.06 | 4.70bcd |
| T8 | Raja Balae | 25.22abc | 17.56d | 14.00bcd | 3.56 | 4.79abcd |
| T9 | Poovan | 23.30cd | 14.00 | 11.69 | 2.32 | 4.26 |
| T10 | Rajapuri | 25.53acd | 15.12 | 9.91 | 5.21cd | 4.42 |
| T11 | Hybrid-1 | 25.48bcd | 16.55 | 11.70 | 4.86d | 5.28ab |
| T12 | Alpan | 20.26 | 15.14 | 9.16 | 5.99abc | 4.45d |
| T13 | Ladan | 22.41 | 17.49d | 14.50bcd | 2.99 | 4.05 |
| T14 | Grand Naine (C) | 19.05 | 18.31cd | 14.01bcd | 4.30 | 4.86abcd |
| T15 | Gandevi Selection (C) | 19.05 | 17.85d | 12.78 | 5.07cd | 4.75bcd |
| T16 | Vadakkan Kadali | 21.70 | 17.06 | 13.75d | 3.31 | 4.78abcd |
| T17 | Matti | 26.58 ab | 18.86bcd | 15.53b | 3.33 | 5.10abc |
| T18 | Chetty | 15.29 | 20.28b | 15.39bc | 4.89d | 5.07bcd |
| T19 | Valiyakunnan | 24.91bcd | 19.20bcd | 13.45d | 5.75abc | 4.88abcd |
| T20 | Chandra Balae | 27.60a | 18.15cd | 14.56bcd | 3.59 | 4.22 |
| T21 | Lalkel | 21.29 | 16.28 | 9.99 | 6.29abc | 4.72bcd |
| T22 | Basrai | 20.00 | 17.26 | 13.64d | 3.62 | 4.81abcd |
| T23 | Jahaji | 17.69 | 17.10 | 13.44d | 3.66 | 4.68bcd |
| T24 | Karpura Chakkakeli | 25.49abc | 22.17a | 17.67a | 4.50 | 4.16 |
| T25 | Parakuni | 19.88 | 17.03 | 11.42 | 5.61bcd | 5.04abcd |
| T26 | Monthan | 24.32bcd | 16.08 | 12.52 | 3.56 | 4.84abcd |
| T27 | Saba | 21.06 | 16.92 | 9.99 | 6.93a | 5.35a |
| T28 | NRCB -10 | 24.67bcd | 18.76bcd | 13.92cd | 4.84d | 4.60cd |
| T29 | Peyan | 20.61 | 19.68bc | 12.95d | 6.73ab | 4.91abcd |
| T30 | Udhyam | 21.08 | 19.16bcd | 13.21d | 5.95abcd | 4.85abcd |
|  | S.Em.± | 1.12 | 0.56 | 0.47 | 0.28 | 0.06 |
|  | CD @ 5% | 3.20 | 1.60 | 1.35 | 0.80 | 0.17 |
|  | CV % | 7.03 | 4.66 | 5.36 | 8.78 | 1.79 |

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| **Table-3: Evaluation of banana genotypes with respect to Ascorbic acid, Acidity, Phenols and Fruit firmness** |
| **Treatments** | **Ascorbic****acid****(mg/100g)** | **Acidity (%)** | **Phenols****(mg/100g)** | **Fruit Firmness****(kg/cm2)** |
| T1 | Elavazhai | 6.45 | 0.35abc | 32.30 | 2.20 |
| T2 | Aktoman | 6.50 | 0.44abc | 36.25ab | 2.05 |
| T3 | Kunnan | 7.31 | 0.34abc | 37.00 a | 3.10cd |
| T4 | Kali | 8.21cd | 0.37abc | 33.41cd | 2.05 |
| T5 | Hannuman | 9.16bcd | 0.39abc | 34.77abcd | 2.55 |
| T6 | Mahalaxmi | 6.39 | 0.31abc | 34.31abcd | 3.20cd |
| T7 | Cv. Rose | 7.14 | 0.44abc | 33.19d | 3.00cd |
| T8 | Raja Balae | 6.39 | 0.34abc | 35.66abc | 3.30cd |
| T9 | Poovan | 10.75a | 0.39abc | 35.97abc | 2.00 |
| T10 | Rajapuri | 9.43bc | 0.36abc | 34.86abcd | 2.55 |
| T11 | Hybrid-1 | 9.13bcd | 0.33abc | 34.88abcd | 3.25 |
| T12 | Alpan | 7.09 | 0.37abc | 34.37abcd | 1.75 |
| T13 | Ladan | 9.25bcd | 0.38abc | 33.80bcd | 1.60 |
| T14 | Grand Naine (C) | 6.46 | 0.54a | 35.49abcd | 3.30cd |
| T15 | Gandevi Selection (C) | 7.23 | 0.46ab | 33.04 | 3.70c |
| T16 | Vadakkan Kadali | 6.35 | 0.52a | 34.31abcd | 2.70d |
| T17 | Matti | 8.19cd | 0.40abc | 35.09abcd | 1.80 |
| T18 | Chetty | 9.31bcd | 0.39abc | 35.84abcd | 1.20 |
| T19 | Valiyakunnan | 8.25cd | 0.38abc | 32.84 | 2.30 |
| T20 | Chandra Balae | 9.05cd | 0.47ab | 34.49abcd | 2.55 |
| T21 | Lalkel | 10.34ab | 0.50ab | 35.21abcd | 3.30cd |
| T22 | Basrai | 9.20bcd | 0.47ab | 35.95abc | 2.65d |
| T23 | Jahaji | 6.40 | 0.44abc | 34.60abcd | 2.95cd |
| T24 | Karpura Chakkakeli | 8.09d | 0.55a | 33.91bcd | 2.45 |
| T25 | Parakuni | 8.38cd | 0.21c | 35.56abcd | 5.50b |
| T26 | Monthan | 9.21bcd | 0.27bc | 32.31 | 6.45a |
| T27 | Saba | 8.68cd | 0.35abc | 33.42cd | 1.40 |
| T28 | NRCB -10 | 7.16 | 0.40abc | 32.52 | 3.45cd |
| T29 | Peyan | 8.02 | 0.21c | 36.39ab | 3.00cd |
| T30 | Udhyam | 0.28 | 0.01 | 1.21 | 0.13 |
|  | S.Em.± | 0.81 | 0.03 | 3.45 | 0.36 |
|  | CD @ 5% | 4.97 | 4.30 | 4.95 | 6.24 |
|  | CV % | 6.40 | 0.44abc | 34.60abcd | 2.95cd |

 Results

Results from Table 3 revealed that Poovan recorded the highest ascorbic acid content (10.75 mg/100g) followed by Lalkel (10.34 mg/100g), Rajapuri (9.43 mg/100g) and Chetty (9.31 mg/100g) indicating their potential as excellent sources of vitamin C. Importance of selecting high-ascorbic-acid genotypes for their potential health benefits, particularly in enhancing dietary vitamin C intake (Borges *et al.,* 2019). Maximum acidity per cent was noted in T25: Parakuni, which was at par with T14: Grand Naine (C) (0.55 % and 0.54 % respectively) while, the minimum acidity per cent (0.21 %) was found in T30: Udhyam and T26: Monthan followed by T27: Saba (0.27 %).This is in agreement with the findings of Ara *et al.* (2011), Parmar and Mor (2018) and Jena *et al.* (2020). In T25: Parakuni had maximum acidity per cent which was at par with T14: Grand Naine (C) (0.55 % and 0.54 % respectively) while the minimum acidity percentage (0.21 %) which was found in T30: Udhyam and T26: Monthan followed by T27: Saba (0.27 %). These observations are in line with the study of Muhammad *et al.* (2020), who reported a decrease in titratable acidity at advanced maturity due to an increase in sugar content. The phenol content (37.00) was significantly higher in T3: Kunnan, which was at par with T30: Udhyam (36.39). However, the minimum phenol content (32.30) was observed in T1: Elavazhai followed by T27: Saba (32.31). Fruit firmness (6.45) was significantly highest in T27: Saba. While the lowest fruit firmness (1.20) was recorded in T18: Chetty. The loss of firmness is one of the most characteristic changes occurring in fresh fruits during ripening. The decrease in firmness during ripening may be due to the breakdown of insoluble proto-pectin into soluble pectin or by cellular disintegration leading to membrane permeability.

**Summary and conclusions**

It is concluded from the biochemical analysis of thirty genotypes that the TSS in banana varieties showed significant variation. Chandra Balae (27.60 °B) had the highest TSS, indicating superior sweetness, while Jahaji (17.69 °B) and Chetty (15.29 °B) had the lowest, making them more suitable for processing. The coefficient of variation was 7.03%, showing moderate variability. Karpura Chakkakeli (22.17%) had the highest total sugar content, followed by Chetty (20.28%), while Aktoman (13.89%) and Poovan (14.00%) had the lowest. Also, it had the highest reducing sugar content (17.67%), while Aktoman had the lowest (9.05%) reducing sugar content. Saba had the highest non-reducing sugar content (6.93%), while Poovan had the lowest (2.32%), indicating moderate variability among varieties. Poovan had the highest ascorbic acid content (10.75 mg/100g), while Vadakkan Kadali had the lowest (6.35 mg/100g) with low variability among varieties. Parakuni had the highest acidity (0.55%) and ascorbic acid content, while Udhyam and Monthan had the lowest acidity (0.21%) and ascorbic acid levels. Kunnan had the highest phenol content (37.00), while Elavazhai had the lowest (32.30) phenol content. Saba had the highest fruit firmness (6.45), while Chetty had the lowest (1.20) firmness. Saba had the highest pH (5.35), while Elavazhai had the lowest pH (4.03).

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