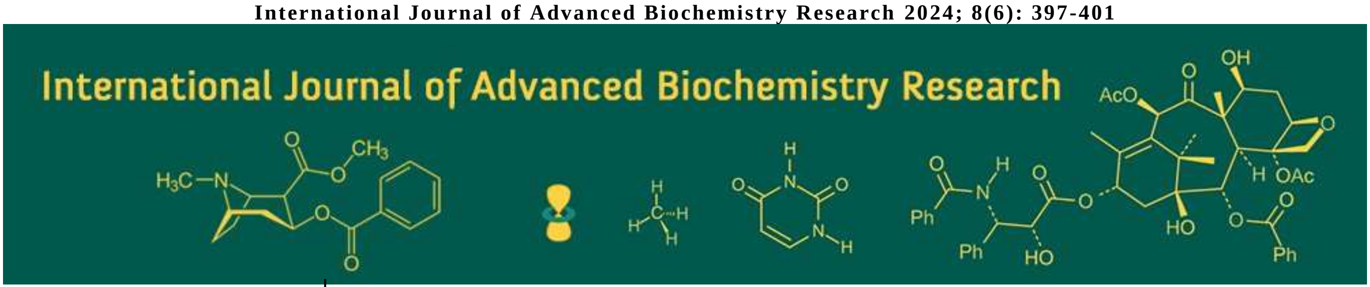

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Characterization of important genotypes of bael (*Aegle marmelos*) for its nutritional value through evaluation of physico-chemical composition

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Abstract
The goal of the current study was to assess the physico-chemical composition of eight genotypes of bael, namely NB-4, NB-5, NB-7, NB-9, NB-16, NB-17, Pant Aparna, and Pant Sujata. Fruit weight, length, and width were measured and found to be at their greatest in NB-7 (2.82 kg, 28.90 cm, and 28.25 cm, respectively). On the other hand, the largest percentage of fruit shell, number of seeds/fruit, and mucilage were found in NB-5, NB-17, and NB-4 (4.21%, 160.00, and 4.71%, respectively). Ascorbic acid, reducing sugar, non-reducing sugar, and total sugars were found in genotype NB-5, corresponding to 23.70 mg, 5.93%, 12.41%, and 18.34%, respectively. The results of chemical parameters were recorded as total soluble solids and acidity, which were maximum in NB-9 and NB-16, at 38.53OB, 0.35%, and less, respectively. The aforementioned genotypes were discovered to have superior physico-chemical content and were therefore suggested for the reproduction and manufacturing scheme.

Keywords: *Aegle marmelos*, physicochemical parameters, genotypes, evaluation

Introduction
Bael (*Aegle marmelos* L. Correa), belonging to the family Rutaceae is an important perennial fruit tree known for its nutrients and traditional uses in indigenous system of medicine. It is known by several names in different languages like wood apple, golden apple, Bengal quince, Indian quince, Sir phal, shreephal, bilva, bilwa, mojo tree, bel, gudu, etc. (Bhar *et al.* 2019) [2]. As per report it was originated from Eastern Ghats and Central India (Sharma and Dubey 2013) [8] and widely distributed in tropical to subtropical regions, growing up to an altitude of 1200 m. from the sea level (Sharma and Dubey 2013) [8]. In India, it is available in the wild in the states of Uttar Pradesh, Orissa, West Bengal, and Madhya Pradesh. It is also cultivated in Nepal, Myanmar, Vietnam, Tibet, Ceylon, Laos, Cambodia, Malaysia, Sri Lanka, Bangladesh, Thailand, Indonesia, the dried areas of Java, Fiji and some parts of the Philippine Islands (Bhar *et al.* 2019) [2]. Bael is a slow-growing, thick-stem, branchy, medium-sized tree attaining 20-25 feet height. It grows well in the dry forests of hilly and plain areas. It is found all over India. In Punjab, it grows up to an altitude of 1,200 m where the temperature rises to 48.89 ºC in the shade in summer and descends to -6.67 ºC in the winter, and prolonged droughts occur. It will not fruit where there is no long, dry season as in southern Malaysia (Sharma and Dubey, 2013) [8]. Leaves are generally trifoliate, alternate, compound, with one pair of shortly stalked, opposite having pulvinus leaflet, ovate or ovate lanceolate, crenate, acuminate and membranous, and midrib prominent beneath (Singh *et al.* 2015; Singh *et al.* 2018) [9, 10]. It is locally grown, sold and eaten. Bael is now being widely planted as boundary plantations or orchards by certain forward-thinking farmers in Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, and Punjab. In the nation, an enhanced type of bael is estimated to be planted on 1000 hectares of land, producing 10,000 tonnes of grain annually.The bael fruit is the richest source of Riboflavin, Marmelosin, Luvangetin, Aurapten, Psoralen, Marmelide, Tannin, Phenol highly nutritive, rich in mineral and vitamin contents like Vitamin A, B, C and high content of carbohydrates (Senthamarai *et al.* 2019) [7]. It contains moisture (61.0%), mineral (1.9%), phosphorus (0.05%), potassium (0.6%),

calcium (0.009%), fiber (2.9%), protein (1.6%), Fat (0.2%), Carbohydrate (30.6%), Iran (0.3%), Vitamin A (IU) (186%), Vitamin B1 (0.01%), Vitamin C (0.01%), Riboflavin (1.2%) and Calorific value (129%) in fruit juice (Neeraj *et al.*, 2017) [4].

Materials and Methods

In the present study, eight genotypes of *Aegle marmelos* were selected as experimental material that was cultivated in main experimental station of horticulture farm situated in Acharya Narendra Deva University of Agriculture and Technology (ANDUA&T), Kumarganj, Ayodhya, India in the year 2022-2023. Geographically, the experimental site is situated between latitude of 24.47 and 26.75 North and longitude of 82.12 and 83.98 East at the elevation of 118 meters above mean sea level.

Collection of plant material

Fruits were gathered from various bael genotypes, including Pant Sujata and Pant Aparna from ANDUA&T, Kumarganj, Ayodhya, India, as well as Narendra Bael-4 (NB-4), Narendra Bael-5 (NB-5), Narendra Bael-7 (NB-7), Narendra Bael-9 (NB-9), Narendra Bael-16 (NB-16), and Narendra Bael-17 (NB-17). For the investigation, fruit that was both ripe and fresh was gathered from the university's experimental bael orchard. Two genotypes, Pant Aparna and Pant Sujata, are varieties created at Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Pantnagar, Uttarakhand, while the remaining six genotypes, NB-4, NB-5, NB-7, NB-9, NB-16, and NB-17, have been developed at ANDUA&T, Kumarganj, Ayodhya, India. (Parthasarthy *et al*. 2021; Singh *et al*. 2019)

Physical parameters of fruit

The various observations were recorded like weight, length, width, diameter, fruit Shell, number of seed/fruit and mucilage, three fruit from each plant were selected randomly and measured, then mean value are presented in Table 1. The length and width of the fruits were recorded as the polar and equatorial diameter of the fruit with the help of measuring tape and expressed in centimeters. For measurement of fruit weight the fruits were weighted on the digital electronic balance and expressed in Kg. The seeds separated from the pulp were thoroughly washed with water then the number of seeds was counted and expressed as number of seeds per fruit. The fruit's shell was removed from the pulp, fruit's shell and pulp were weighed separately on the digital electronic balance. The shell percent was calculated with the help of the formula.

$$\text{Shell (\%)} = \frac{\text{Shell weight of the fruit}}{\text{total weight of fruit}} \text{x } 100$$

To estimate the mucilage percentage in a fruit, the seeds with the mucilage are separated and weighed on electronic balance then washed thoroughly with water thereafter weight of the seeds is recorded by the electronic balance. The mucilage percentage content concerning fruit weight was estimated using the formulae mentioned hereunder.

$$\text{Mucilage content (\%)} = \frac{\text{Weight of mucilage with seeds (g)} - \text{Weight of seeds (g)}}{\text{Weight of fruits (g)}} \text{x } 100$$

Chemical parameters of fruit: The T.S.S., Acidity, Ascorbic acid, Non-reducing sugar, Reducing sugar, and Total sugars were recorded, three fruit from each plant were selected randomly and measured then mean value are presented in Table 2.

T.S.S (°Brix): To extract juice, fruits were left to be macerated in a pestle and mortar after being chosen at random from each treatment. The total soluble solids (TSS) of the juice were calculated with an Erma hand refractometer, which had an accuracy range of 28-62 percentage and 0-32 percentages. The data were converted to the percent total soluble solids of bael fruit pulp in ^Brix after being adjusted at 20 °C (Ranganna, 1986) [6].

Acidity (%): Ten grammes of known-to-be-fruit pulp were macerated, diluted with a small amount of distilled water, and then filtered through muslin fabric. The amount was increased to 100 ml, and an aliquot of 5 ml was collected for titration using the phenolphthalein indicator against a 0.1 N sodium hydroxides solution. The endpoint was designated as the appearance of a light pink colour. Kaur and Kalia (2017) [3] computed the results using the following formula and represented them as a percentage of acidity per 100 grammes of fruit pulp.

$$\text{Acidity (\%)} = \frac{\text{Titrate value} \times \text{Normality of alkaline} \times 64 \times \text{volume made up}}{\text{Aliquottaken} \times \text{weightofsample} \times 1000} \text{x } 100$$

Ascorbic Acid (mg/100g): Ascorbic acid content was estimated by grinding 5 g fruit pulp with 3.0 percent Metaphosphoric acid as buffer. The extract was filtered with muslin cloth, and the volume was made up to 50 ml. A suitable 5 ml aliquot was taken for a titration against, 2, 6-dichlorophenol indophenol dye solution the appearance of light pink colour persisting at least for 15 second and procedure was fallowed as described by Rangana (1986). Dye factor expressed the mg of ascorbic acid per ml of dye solution. The results were calculated with the help of formula and expressed as mg ascorbic acid per100g of fruit pulp (A.O.A.C., 1980) [1].

$$\text{Dye Factor} = \frac{0.5}{\text{Titrate volume of standard ascorbic acid}}$$

$$\text{Ascorbic Acid} = \frac{\text{Titer value x Dye factor} \times \text{Volume madeup}}{\text{Aliquot of extract taken x Weight of sample}} \text{x } 100$$

Non-reducing sugars (%): Non-reducing sugar was calculated by deducting the quantity of reducing sugar from total invert sugars and multiplied by factor 0.95. The result was expressed as percent of non-reducing sugar.

Non-Reducing Sugar (%) = [Total Invent Sugars (%) - Reducing Sugars (%)] × 0.95

Reducing sugar (%): To prepare a 10 ml solution of Fehling 'A' and 'B', an aliquot of 5 ml diluted fruit juice was obtained from the 100 ml of juice that was previously used for titration. Using methyl blue as an indicator, this was titrated against 1.0 percent glucose in boiling solution. Additionally, 10ml of Fehling 'A' and 'B' were run as a blank. The outcome was given as the percentage of sugar reduction. Using methyl blue as an indicator, this was titrated under boiling conditions against a dextrose solution (1 millilitre = 205 mg dextrose). To standardise the feeling's solution, a blank containing 5 ml of each feeling "A" and "B" solution was also titrated under boiling conditions against the identical dextrose solution. The methyl blue indicators and the emergence of brick-colored cuprous oxide precipitates signal the endpoint. The outcome was computed using the procedure below and reported as a percentage of decreasing sugars.

$$\text{Reducing sugar (\%)} = \frac{[\text{Blank Tv} - \text{Sample Tv}] \times 0.0025 \times \text{volume made up (ml)}}{\text{Aliquot taken (ml) x Weight of sample (g)}} \text{x } 100$$

Total Sugars (%): Lane and Eynon's Fehlings "A" and "B" solution method was used to estimate sugar content (1943). A 100 ml volume was created by macerating 10 g of fruit pulp in a pestle and mortar with a tiny amount of distilled water and filtering the mixture through muslin cloth. Total sugar was calculated by adding together the percentages of reducing and nonproducing sugar.

Total Sugar (%) = Reducing sugar (%) + non-reducing sugar (%)

Statistical Analysis

The data recorded from the experiment were analyzed by ANNOVA statistical software for each treatment.

Results and Discursion

Physical parameter of fruit

Physical characteristics like weight, length, width, fruit shell, number of seeds per fruit, and fruit mucilage were estimated after the fresh and ripped fruits were gathered from eight genotypes of bael that were chosen. Significant differences in physical parameters were noted across the genotypes; table 1 and figure 1 provide further information on these factors. The fruit weighed NB-7 (2.82 kg) at its greatest, NB-17 (1.92 kg), Pant sujata (1.50 kg), Pant aparna (1.20 kg), NB-5 (1.16 kg), NB-9 (1.13 kg), NB-16 (0.93 kg), and NB-4 (0.71 kg) at its minimum. Singh and others. Singh *et al.* 2014 [13] Furthermore indicated as fruit weight, the lowest fruit weight was found in NB 16 (0.43 kg), followed by CISHB 1 (0.96 kg), and the greatest weight in NB-7 (4.25 kg), Pant urvashi (2.90 kg), CISH-B 2 (2.58 kg), and Pant Shivani (2.45 kg). The longest fruit length measured was 28.90 cm in NB-7, and the shortest was 13.40 cm in NB-5. Other fruit lengths that were measured were 24.90 cm in NB-17, 24.50 cm in NB-9, 24.26 cm in pant aparna, 24.12 cm in pant sujata, and 17.16 cm in NB-16. according to Singh *et al.* (2014) [13], fruit length (19.59 cm) was found to be lowest in NB-16 (10.61) and to be highest in CISH-B 2 and Pant shivani, followed by NB 9 and Pant urvashi. followed by pant sujata (24.31 cm), NB- 17 (24.04 cm), pant aparna (23.17 cm), NB-9 (22.46 cm), NB-16 (17.04 cm), NB-4 (15.31 cm) while minimum was NB-5 (12.35 cm). According to Singh *et al.* 2020 [12], fruit breadth was also recorded as minimum (12.50 cm) in NB-5 and much larger (16.28 cm) in NB-7, which was statistically comparable to NB-9 (13.46 cm). Highest fruit shell was found in NB-5 (4.21%), minimum in NB-7 (3.48%), and highest in NB-16 (4.12%), NB-17 (4.08%), NB-4 (4.06%), Pant sujata (3.84%), NB-9 (3.69%), and Pant aparna (3.59%). In genotype NB-17 (160.00), the most seeds were found per fruit; they were followed by NB-16 (152.00), NB-4 (115.19), NB-5 (110.40), NB-9 (108.67), NB-7 (95.00), Pant sujata (94.33), and Pant aparna (87.67). According to Singh *et al.* (2014) [13], NB 16 had the highest percentage of shell and total seed, calculated at 26.80 and 5.05, respectively, while Goma Yashi (11.76) and CISH-B 2 (0.80) had the lowest percentages of shell and seed, respectively. Fruit mucilage was highest in NB-4 (4.71%), lowest in Pant sujata (3.70%), and followed by NB-16 (4.53%), Pant aparna (4.38%), NB-9 (4.25%), NB-7 (4.12%), NB-17 (4.02%), and NB-5 (3.79%). According to Singh *et al.* 2014(A) [13], NB-9 (14.5%) had the highest mucilage content, followed by Pant shivani (13.80%), CISHB-2 (13.51%), and Pant urvashi (13.27%).

Table 1: Physical parameter of different selected genotypes of bael fruit

Treatments	Parameters					
	Fruit weight (kg)	Fruit length (cm)	Fruit width (cm)	Fruit shell (%)	Number of seeds per fruit	Fruit mucilage (%)
NB-4	0.71	16.71	15.31	4.06	115.19	4.71
NB-5	1.16	13.40	12.35	4.21	110.40	3.79
NB-7	2.82	28.90	28.25	3.48	95.00	4.12
NB-9	1.13	24.50	22.46	3.69	108.67	4.25
NB-16	0.93	17.16	17.04	4.12	152.00	4.53
NB-17	1.92	24.90	24.04	4.08	160.00	4.02
Pant Sujata	1.50	24.12	24.31	3.84	94.33	3.70
Pant Aparna	1.20	24.26	23.17	3.59	87.67	4.38
SEm±	0.03	0.31	0.36	0.05	1.24	0.06
CD at 5%	0.08	1.06	0.35	0.17	3.76	0.24

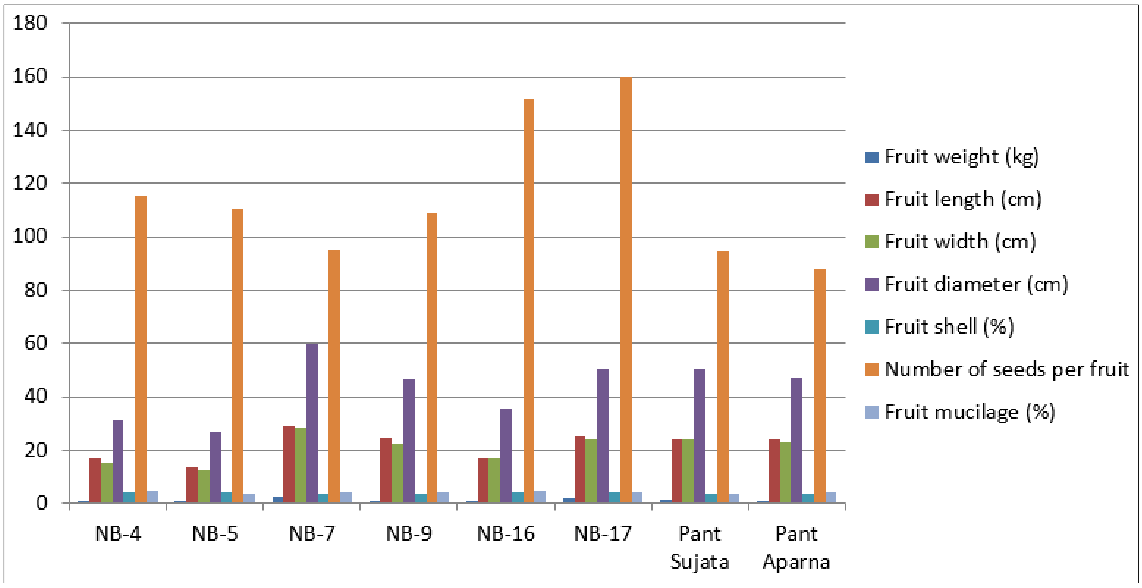

Fig 1: Physical parameter of different selected genotypes of bael fruit

Chemical parameter of fruit

Chemical parameter such as T.S.S., acidity, ascorbic acid, reducing sugar, non-reducing sugar and total sugars were observe in selected eight genotypes of bael. Significance variances of chemical parameters were seen among the genotypes and the detail of chemical parameters are given in table 2 and illustrated in figure 1. A perusal data of table 2 revealed that the total soluble solids was found highest in genotype NB-5 (38.53 ^{O}B) followed by Pant sujata (38.51 ^{O}B), Pant aparna (37.92 ^{O}B), NB-17 (37.28 ^{O}B), NB-9 (36.23 ^{O}B), NB-7 (32.56 ^{O}B), NB-4 (32.25 ^{O}B) and lowest was seen in NB-16 (28.43 ^{O}B). Singh *et al.* 2020 [12] reported maximum TSS (30.2%) was observed in NB-9, being at par with NB-5 (29.7%). It was lowest (27.8%) in NB-7. Acidity among the genotypes was seen highest in the NB-16 (0.35%) followed by NB-4 (0.32%), NB-7 (0.31%), NB-9 (0.29%), NB-17 (0.28%), Pant aparna (0.27%), Pant sujata (0.26%) and lowest was seen in NB-5 (0.25%). Singh *et al.* 2020 [12] reported fruit acidity was observed significantly higher (0.48%) in NB-9, which was statistically at par with NB-7 (0.46%) while minimum fruit acidity (0.42%) was recorded in NB-5. Ascorbic acid was seen maximum in NB-5 (23.70 mg) followed by Pant sujata (22.75 mg), Pant aparna (21.58 mg), NB-9 (21.49 mg), NB-16 (19.81 mg), NB-7 (19.29 mg), NB-4 (19.18 mg) and minimum was seen in NB-17 (19.07 mg). Singh *et al.* 2014 [13] reported that the maximum Vitamin 'C' content was found in Goma Yashi (21.03 mg/100 g) followed by NB 5 (20.63 mg/100 g) and NB 7 (19.78 mg/100 g) and the same was observed the minimum in Pant sujata (17.13 mg/100 g) followed by Pant aparna (17.15 mg /100 g). Reducing sugar was recorded highest in NB-5 (5.93%) followed by Pant sujata (5.87%), Pant aparna (5.67%), NB-17 (5.37%), NB-9 (5.19%), NB-7 (4.80%), NB-16 (4.60%) and lowest was seen in NB-4 (4.56%). Singh *at al.* 2014(A) [13] reported that the highest reducing (4.87%) and non-reducing sugar content (15.13%) was estimated in CISHB-1 and NB-9, respectively. Non-reducing sugar was observe maximum in NB-5 (12.41%) followed by Pant suajata (12.20%), Pant aparna (12.11%), NB-17 (11.81%), NB-9 (11.68%), NB-7 (11.42%), NB-4 (11.27%) and minimum was seen in NB-16 (11.02%). Total sugars was recorded highest in NB-5 (18.34%) followed by Pant sujata (18.07%), Pant aparna (17.78%), NB-17 (17.24%), NB-9 (16.87%), NB-7 (16.22%), NB-4 (15.83%) and lowest was seen in NB-16 (15.62%). Singh *at al.* 2014 [13] reported that the total sugars was found maximum in NB 9 (19.98%) followed by Pant aparna (19.93%), whereas the same was recorded the minimum in Pant urvashi, NB 7 (16.15%) and NB 17 (16.60%).

Table 2: Chemical parameters of different selected genotypes of bael fruit

Treatments	Parameters					
	T.S.S ^{0} (Brix)	Acidity (%)	Ascorbic Acid (mg	Reducing sugar (%)	Non-reducing sugars (%)	Total Sugars (%)
NB-4	32.25	0.32	19.18	4.56	11.27	15.83
NB-5	38.53	0.25	23.70	5.93	12.41	18.34
NB-7	32.56	0.31	19.29	4.80	11.42	16.22
NB-9	36.23	0.29	21.49	5.19	11.68	16.87
NB-16	28.43	0.35	19.81	4.60	11.02	15.62
NB-17	37.28	0.28	19.07	5.37	11.81	17.24
Pant Sujata	38.51	0.26	22.75	5.87	12.20	18.07
Pant Aparna	37.92	0.27	21.58	5.67	12.11	17.78
SEm±	0.57	0.01	0.35	0.08	0.17	0.26
CD at 5%	1.72	0.02	1.07	0.25	0.50	0.77

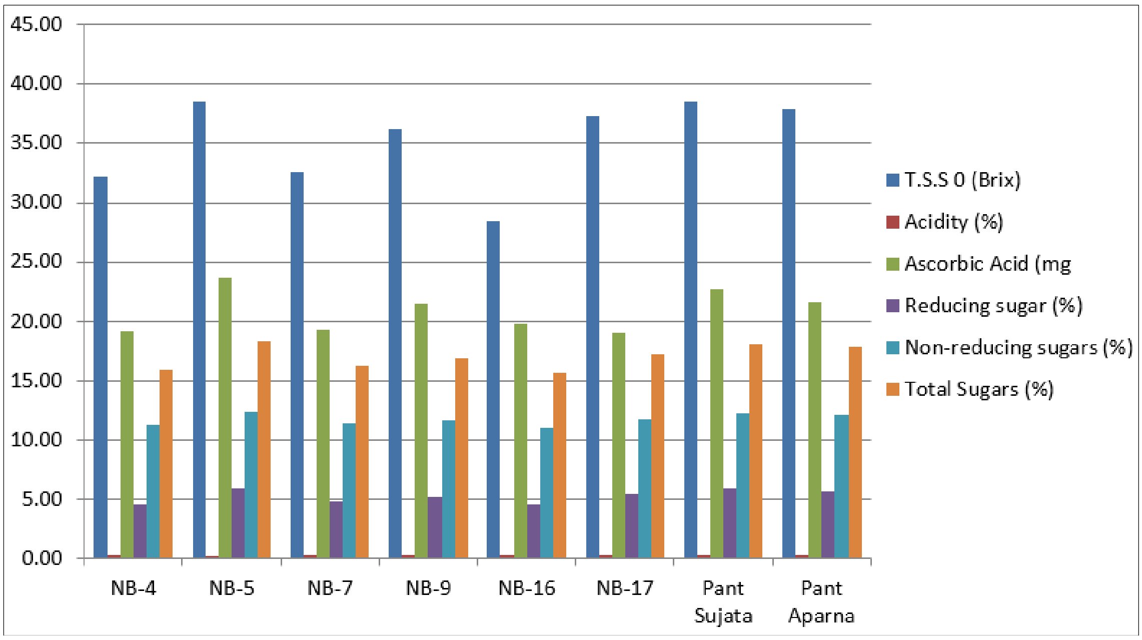

Fig 2: Chemical parameter of different selected genotypes of bael fruit

Conclusion

According to the data analysed in the result, genotype NB-9 was observed to be better for fruit weight, length, width, diameter, and total soluble solids; genotypes NB-5, NB-17, and NB-4 were observed to be better for the highest fruit shell, number of seeds/fruit, and mucilage, respectively; genotype NB-5 was observed to be better for ascorbic acid, reducing sugar, non-reducing sugar, and total sugar; and genotype NB-16 was observed to be better for acidity.

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Conflict of interest

The authors declared that there is no conflict of interests or personal relationships that could have appeared to influence the work reported in this paper.

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