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Comparative physico-chemical evaluation of Bael (*Aegle marmelos* (L.) Correa) genotypes

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Abstract
Bael is an underutilised, native fruit with an excellent nutritional profile. Bael fruits follow a single sigmoid curve and are categorized as climacteric fruits, ripening 10 to 11 months after fruit set. An experiment was laid out during 2020-21 to analyse the change in the physicochemical characteristics of fruits of different genotypes at the maturation and ripening stage. The research was carried with four replications of each of the four bael genotypes (NB-4, NB-5, NB-7, NB-9) in a completely randomised design at the Main Experimentation Station, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya. The results of the study demonstrated an increase in fruit weight, a nearly constant fruit size, and a decrease in the proportion of mucilage as the fruit ripens. Total soluble solids, sugars, and ascorbic acid increased between the maturation and ripening stages of fruit, although acidity decreased. NB-7 has the greatest size and fruit weight, NB-5 has the least mucilage (percent), the least acidity, and a greater amount of TSS, NB-4 has the maximum reducing sugars, non-reducing sugars, and total sugars, whereas, NB-9 has the greatest ascorbic acid content at ripened stage.

Keywords: Bael, physico-chemical, genotype, completely randomized design

Introduction
Bael fruit (*Aegle marmelos* (L.) Correa) is one of the important fruit known in India from prehistoric times. It was originated in the Eastern Ghats and central India, belongs to family Rutaceae; sub-family aurantiodeae; and comes under hard shelled citroid fruit tree group. fruit grown in the states under tropical and subtropical climate. Besides India, it is also found in Myanmar, Sri Lanka, Bangladesh, Pakistan, Thailand, Indonesia, Combodiana, Vietnam, Central African countries. It has high tolerance to arid conditions as well as high rainfall. Bael tree is held sacred by Hindus and offered in prayers of deities Lord Shiva and Parvati and thus the tree is also known by the name Shivaduma (The Tree of Shiva). Aegle is monotypic genera with deciduous leaves. Tree gains a height of 10 to 15m. It has greyish stem and irregular furrows on the younger branches with sharp axillary thrones and trifoliate leaves. It bears sweet scented, greenish white flowers about 1-2 cm wide on axillary or terminal cymes. Flowers are bisexual contains numerous stamens and oblong ovary. Fruits are globose with grey or yellowish hard woody shell. Inside this, there is soft yellow or orange coloured mucilaginous pulp with numerous seeds. It has numerous seeds, which are densely covered with fibrous hairs and are embedded in a thick, gluey, aromatic pulp. Bael fruits follows single sigmoid curve. The growth pattern of bael comprises of three different phases; the initial slow increase for one month followed by rapid increase for four months and then more or less a stationary phase until fruits are harvested. On basis of respiratory behavior bael is classified as climacteric fruit. It takes 10-11months to attain maturity from fruit set. Under North Indian conditions the bael matures in December - January while fruits normally ripen in April because of low temperature prevailing in North during December – February (Roy and Singh 1980. Fruit development stages (FDS) are associated with significant changes in Total soluble solids, sugars, acidity and poly-phenol content. With the fall in the rate of increase in mucilage, the starch appeared and continued to increase during development thereafter disappear with ripening. Total and reducing sugars showed a rising trend during development and rapid increase during ripening whereas the acidity showed a downward trend during development and ripening of fruits. Total phenolics and leucoanthocyanin content of bael fruits decreased during the development and ripening.

Materials and Methodology
The present investigation was carried out at Main Experimentation Station, Horticulture,

Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) in the year 2020-21 the healthy fruits free from disease, pest and bruises were randomly selected from the main experiment station, Horticulture, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya (U.P) India for the comparative physico-chemical analysis of different genotypes of bael.

Fruit weight of fruit was measured through the digital weight balance, fruit size was measured through the scale and measuring tape. TSS was estimated by using a hand refractometer (Erma) of 0 to 32% and 28-62% range at room temperature and the reading was corrected at 200 C temperature. Sugars was estimated by using Fehling solution 'A' and 'B' as per method given by Lane and Eynon (1923) and Ranganna, 2010 [18] The acidity and ascorbic acid was estimated as per method described by (A.O.A.C., 1970), the alcohol estimation was done by experts of RFRAC Lucknow through the procedure described in FSSAI Manual Fruits & Vegetable (2016) [18]. Statistical analyses of the data obtained in the experiments were calculated as suggested by Panse and Sukhatme (1985) [15] and results were evaluated at 5% level of significance.

Result and Discussion

The data arranged in the Table 1 reveals significant difference in fruit weight of different genotypes. The weight of the fruits increased during the ripening. Among the genotypes maximum increase in fruit weight was observed in NB-7. The rise in weight may be attributed to cell division, cell enlargement, and the accumulation of water and food contents within the fruits. Absorption of water and minerals, photosynthesis, and respiration rate significantly influence the growth and development of fruits. Wongmetha *et al*. (2015) [22] reported similar findings on mango fruit cv. Jinhwag, Patel *et al*. (2014) [16] in passion fruit, and Devi *et al*. (2020) [22] in canola.

Table 1: Change in the physico-chemical characteristics of different genotypes of bael from maturity to ripening of fruits

Genotypes	Fruit weight (g)		Fruit Length (cm)		Fruit width (cm)		Mucilage (%)		Acidity (%)		Ascorbic acid (mg/100g pulp)	
	Matured	Ripened	Matured	Ripened	Matured	Ripened	Matured	Ripened	Matured	Ripened	Matured	Ripened
NB-4 (V_1)	1299.54	1355.82	12.56	12.6	12.55	12.61	4.21	4.61	0.401	0.351	20.70	21.87
NB-5 (V_2)	1530.53	1600.28	13.29	13.34	13.10	13.15	3.45	3.74	0.365	0.316	20.40	21.56
NB-7 (V_3)	3897.90	4026.1	19.38	19.45	19.54	19.6	3.51	3.96	0.445	0.392	17.96	19.16
NB-9 (V_4)	1852.43	1945.31	17.04	17.05	16.35	16.42	3.62	4.12	0.351	0.325	21.30	22.34
S.Em±	11.86	10.85	0.13	0.19	0.20	0.11	0.05	0.05	0.003	0.005	0.21	0.21
C. D. at 5%	36.53	33.42	0.40	0.59	0.60	0.35	0.14	0.15	0.008	0.015	0.66	0.64

The change in fruit size was remained constant from maturation to the ripening. NB-7 genotypes had largest fruit size (19.38 × 19.54 cm) followed by NB-9. Constant size of fruits after maturation to ripening may be due to fact that the maximum cell division and cell enlargement takes place up to the maturity stage after which the growth of fruit ceases. Lal (2002) [9] and Kaushik *et al.* (2002) [5] reported similar results in bael fruits. Li *et al.* (2010) [11] in pineapple and Lakso *et al.* (2013) [8] in apple fruits.

Mucilage percentage was increased with the ripening. Among the genotypes significant difference in the mucilage percentage was observed in fruits. NB-4 has the maximum mucilage percentage (4.61 %) at the ripening stage. The variation among the genotypes may be due to the variation in morphological and genetical traits of cultivars and the synthesis of more mucilage when fruit proceed to maturity and ripening. Sawale *et al.* (2018) [20], and Pandey *et al.* (2019) [14] in ber also reported increase in the mucilage content during the development of bael fruits.

The titrable acidity as decreased with the ripening of bael fruits. Among the genotypes NB-5 has lowest acidity percentage (0.316%) followed by NB-9 (0.325 %) however maximum acidity (0.392%) was recorded in NB-7. The decrease in the acidity might be due to the rapid utilization of organic acids and hydrolysis of organic acids to their salts and sugars. The results are in close agreement of Kaur and Kalia (2017) [4] in bael also reported decrease in the acidity during maturing and ripening.

Similarly, the ascorbic content of the bael fruits was also increased from the maturity to ripening. Genotype NB-9 has the highest ascorbic acid content (22.34 mg/100tg pulp) at the ripening followed by NB-4 (21.87 mg/100g pulp) whereas minimum (19.16 mg/100g pulp) was recorded in NB-7. The increase trend in the ascorbic acid may be due to synthesis of glucose -6 – phosphate, which served as a precursor of ascorbic acid synthesis in fruits. Similar results were also reported by Sawale *et al.* (2018) [20]; Kumar and Deen (2017) [7] in wood apple.

That arranged in table 2 shows increase in TSS from maturation to the ripening. The maximum TSS (35.21 ^{0}Brix) was recorded in genotype NB-5 followed by NB-9 (34.51 ^{0}Brix) whereas the minimum (31.32 ^{0}Brix) was recorded in NB-7. The increase in the TSS might be due to high rate of accumulation of food materials and the hydrolysis of polysaccharides in to simple sugars. Sahu *et al.* (2018) [19] reported increase in TSS during growth and development of ber fruits. Narayan *et al.* (2020) [12] stated a gradual increment in total soluble solids and ascorbic acid with the maturation of aonla fruit cv. NA-10. Sawale *et al.* (2018) [20] also reported increase in TSS from maturity to ripening stage in bael.

The reducing sugars, non-reducing sugar and total sugars all were found increasing from maturity to ripening of bael fruits. Among the genotypes maximum reducing sugars (5.52%), non-reducing sugar (10.65%) and total sugars (16.30 %) were found in the NB-4 follower by NB-9 (reducing sugars (4.45 %), non-reducing sugar (8.82%) and total sugars (13.28%)) whereas the lowest (reducing sugars (5.30%), non-reducing sugar (10.25%) and total sugars (15.55 %) sugars were found in NB-7 of the ripened fruits. The increase in reducing sugars may be due to conversion of starch into sugars during growth and development of fruits. Jana *et al.* (2017) [3] also reported increase in reducing sugars in bael. The tendency of increment of non-reducing sugar during the growth and development may be due to availability of starch amount to hydrolyze into sugars. similar results were also reported by Ram and Singh (2003) [17] in bael and Trong *et al.* (2021) [21] reprted increase in non-reducing sugars during growth and development of litchi. The increase in total sugars may

account due to the combined effect of increasing reducing and non reducing sugar. Similar findings also reported by Kulkarni *et al.* (2011) [6] in banana, Padmavathamma and Hulmani (2006) [13] in pomegranate

From the maturation to ripening, the carotenoids were increasing. NB-9 has the highest carotenoid content (36.1 µg/100g pulp) followed by NB-5 (32.1 µg/100g pulp) whereas the minimum (26.9µg/100g pulp) was contained in the NB-7 genotype. The increase in the carotenoids may be due to conversion of chlorophyll into carotenoids as fruits approached to maturity. Similar results were also reported by Jana *et al.* (2017) [3] in bael

Table 2: Change in the sugars and carotenoids of different genotypes of bael from maturity to ripening of fruits

Genotypes	TSS (^{0}Brix)		Reducing Sugars (%)		Non- Reducing Sugar (%)		Total Sugars (%)		Carotenoids (µg/100g pulp)	
	Matured	Ripened	Matured	Ripened	Matured	Ripened	Matured	Ripened	Matured	Ripened
NB-4 (V_1)	27.21	32.82	5.52	5.65	10.24	10.65	15.76	16.30	22.6	29.66
NB-5 (V_2)	31.24	35.21	4.68	4.78	9.41	9.70	14.09	14.48	23.2	32.1
NB-7 (V_3)	26.51	31.32	4.31	4.45	8.51	8.82	12.82	13.27	20.5	26.9
NB-9 (V_4)	29.62	34.51	5.15	5.30	9.62	10.25	14.77	15.55	28.74	36.1
S.Em±	0.25	0.36	0.07	0.05	0.12	0.10	0.11	0.16	0.23	0.07
C. D. at 5%	0.77	1.11	0.22	0.15	0.36	0.31	0.34	0.50	0.72	0.22

Conclusion

Based on the results, it can be concluded that fruit weight, mucilage percentage, ascorbic acid, TSS, Reducing sugars, non-reducing sugar and total sugars were increasing from maturity to ripening whereas, fruit size was remained constant and acidity decrease with ripening. Overall NB-5 was proved best quality fruits followed by NB-9 and NB-4. NB-7 has the biggest and heaviest fruits.

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