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Study of physico-chemical characteristics of bael (*Aegle marmelos*) fruit

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Abstract
Bael (*Aegle marmelos*) is an important indigenous fruit of India, drought resistance and hardy fruit plant of semi-arid and arid region belongs to Rutaceae family of citrus fruit. The focus on plant research has increase all over the world and large body of evidence has collected to show great potential of medicinal plant used in various systems from several years ago. The present investigation was undertaken to find out physico-chemical characteristics of Bael fruit. The result show that the physical and chemical properties of Bale (*Aegle marmelos*) fruit which is hard and tough outer covering shell. Fruit size in terms of length and diameter, shape and number of seeds per fruit did not change significantly. Fruit weight varies between green and ripe fruit. The nutritional value of Bael fruit was assessed using chemical method. Chemical analysis indicates increase of moisture content 62.04% observed at matured stage. Titratable acidity, pH and crude fibre 0.43%, 4.2%, 4.07% respectively were found. While TSS, moisture, fat, ascorbic acid, reducing and total sugar increased during ripening. Total soluble solids increase significantly from matured stage (8.3^0Bx) to ripened stage (18^0Bx). The objectives of the present study were to study the physicochemical properties of Bael fruit.

Keywords: Bael, *Aegle marmelos*, physical properties, chemical composition and medicinal plants

Introduction
Bael (*Aegle marmelos*) is an important indigenous fruit of India and subcontinents and has great mythological religious significance. It is known from pre-historic time and has been mentioned in the ancient system of medicinal. It is one of the most important plant of India. Bael plant belongs to Rutaceae family, the family of citrus fruit. It is known with different name in different languages such as Bel, Beli, Belgiri, Bilva, Shivphala, Golden apple, Bengal quince, billa patra, balwa etc. in India. Bael is an important drought resistant and hardy fruit plant of semi-arid and arid regions. Each and every part of this Bael fruit i.e. fruit, seed, trunk, bark, leaf, and root are important ingredients of several Ayurvedic prescriptions (Jauhri *et al*. 1971) [3]. Medicinal uses of Bael fruit are uncountable. Various parts of the Bael plants are used in Ayurveda and Unani medicine for treatment of variety of diseases, including treatment of diarrhoea, dysentery, and dyspeptic symptoms. Bael is one of the most nutritious fruit. The fresh fruit is not consumed freely because of eating difficulties due to its hard shell, mucilaginous texture, numerous seeds, and fibres. Seeds are flattened oblong, about 1 cm long, bearing woolly hairs and each enclosed in a sac of adhesive, transparent mucilage that solidifies on drying. The pulp has attractive colour and contains an excellent aroma, which is not destroyed even after processing (Singh *et al.*, 2005) [7].
Bael fruit has numerous uses in day today life. Physicochemical studies prove that Bael fruit is rich in nutritional value, and this is being used from several years ago. The uses of Bael fruit in aspects of food have many forms in each country. For example, the ripe fruit is consumed fresh and also prepared as nectar, squash, sherbet, jam, marmalade, and cream in India (Morton, 1987) [4]. The objectives of the present study were to study the physicochemical properties of Bael fruit.

Materials and Methods
Plant material
Matured ripe Bael fruits having greenish yellow colour, fully ripe Bael fruit were collected from the campus of VNMKV, Parbhani (Maharashtra) for experimental purpose.

Physical properties of bael fruit
The physical characteristics of Bael fruit were studied. Matured green and ripe, healthy fruits with uniform size, colour, and maturity were selected. The length, width, diameter, and average weight were measured.

Specific gravity, volume, and total soluble solids were also measured. The flesh was removed with the help of knife or the spoon manually and separated rind and seeds and their weights were recorded separately. All linear measurements were taken by using Vernier calliper. Where quality attributes like colour, appearance, shape, uniformity and defects were recorded visually.

1. Average weight
The weight of randomly selected three fruits was taken individually on an electronic weighing balance. Then average weight of fruit was calculated and expressed in grams.

2. Average length
The length of five fruits measured with help of Vernier Caliper and average calculated and expressed in cm.

3. Average diameter
The diameter of five fruits was measured and then average was calculated and expressed in cm.

4. Number of seeds per fruit
The number of seeds per fruit of five fruit was measured manually then average was calculated and expressed in number.

5. Thickness of rind
Thickness of rind of five fruits was measured by Vernier Caliper and then average was calculated and expressed in mm.

6. Volume
For measuring the volume, the fruits were put in a measuring cylinder. The water was poured in this measuring cylinder up to the mark (A ml). After a few minutes the water was drained in another measuring cylinder and noted the volume of water (B ml). Volume displaced by fruits = (A -B) ml.

7. Specific gravity
The specific gravity of the fruits was calculated by applying the formula as given below:

$$\text{Specific gravity (g/cc)} = \frac{\text{Weight of fruits}}{\text{Volume of water displaced}}$$

8. Pulp yield
It is ratio of edible part of fruit i.e. pulp to total weight of fruit multiplied by 100. Pulp yield was calculated and expressed in percent.

$$\text{Percent edible index} = \frac{\text{Pulp weight}}{\text{Total weight of fruit}} \times 100$$

9. Waste index
It is ratio of waste part of fruit i.e. pomace to the total weight of fruit multiplied by 100 and expressed in percentage.

$$\text{Percent waste index} = \frac{\text{Weight of waste}}{\text{Total weight of fruit}} \times 100$$

Chemical properties of bael fruit pulp
Extraction of pulp from bael fruits
Prior to extraction of pulp, firstly ripe Bael fruits of uniform maturity, having greenish yellow color were selected. Then flesh of fruit was separated manually from rind, fiber, and seeds. The Bael fruits were thoroughly washed in running tap water and broken by striking against hard surface. The fruit flesh along with its seeds and fiber were scooped out with the help of stainless steel spoon. An equal amount of water to the weight of pulp was mixed which was kneaded, heated for 1 minute at 80 ^{0}C and passed through pulper to obtain homogenized pulp free from seeds and fiber. (Nidhi *et al*., 2007) [5].
For analysing chemical properties of the fruit, the fruit were broken and pulp, seed and pericarp of fruit were separated. Moisture, titrable acidity, crude fibre, crude fat, crude protein and ash content were estimated by employing the standard methods of analysis. pH was measured by control dynamic digital pH meter. Total sugar content was estimated by the phenol-sulfuric acid analysis using glucose as standard. The nature of the carbohydrate was confirmed by Molisch tests, Felhing's test and Iodine test. The total carbohydrate content was determined by anthrone method.

1. Moisture
Moisture refers to the amount of free water and volatile substances that are lost by drying the food under controlled temperature in Hot air oven. It is expressed in g per 100 g sample.

2. Crude fat
5 g sample was weighed accurately in thimble and defatted with petroleum ether in Soxhlet apparatus for 6-8 hrs. at 70 ^{o}C. The resultant ether extract was evaporated and crude fat content was calculated (A.O.A.C. 1990) [1].

3. Total ash
Total ash was determined according to A.O.A.C. (1990) [1]. 5 gm sample was weighed into crucible and ignited at low flame till all the material was completely charred. Then it was kept in muffle furnace for 6 hrs. at 550 ^{o}C and further cooled in desiccators and weighed. This was repeated till two consecutive weights were constant and percent ash was calculated.

4. Acidity as percent citric acid
The acidity of sample was calculated by standard A.O.A.C. method (1990) [1]. Acidity was expressed as percent citric acid.

$$\text{Percent acidity as citric acid} = \frac{\text{Titer x Normality of NaOH x Volume made up x 64 x 100}}{\text{Volume taken for estimation} \times \text{Wt. / volume of sample taken} \times 1000}$$

5. Ascorbic acid
The ascorbic acid was determined by method of Ranganna (1986) [6].
Dye factor = 0.5 Titer value

$$\text{Ascorbic acid mg/100 ml} = \frac{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample taken for estimation}}{\text{Titer x Dye factor x Volume made up x 100}}$$

6. Dietary Fiber

Total dietary fiber were analysed according to standard AOAC methods (AOAC, 1995) [2].

Result and Discussion

The physical characteristics of fruit play a very important role in development of processing technology and on the quality of final products. Quality of any fruit can be judge by the physical parameter. The data on physical characteristics of ripened Bael fruits are presented in Table 1. The colour of Bael fruit changes from greenish yellow to yellowish orange, during the ripening change in colour may be due to degradation of chlorophyll content and formation of carotenoid pigments. The peel of fruit was very hard shell and green to brown in colour depends upon the ripening stage. Fruit size in terms of length and diameter, shape and number of seeds/ fruit did not change significantly. Fruit weight varies between green and ripe fruit. The values for fruit length observed 9.3 cm. Diameter of Bael was found to be 6.4 cm. The average weight of three fruits was noted to be 210 grams. Thickness of matured fruit was 6.2mm which is decreased during ripening (4.3mm). Similarly, weight and volume of the fruit gradually increased during development of fruit. A slight increase in specific gravity was also observed during development of fruit. It may be due to physiological development of fruit. The specific gravity of the ripen fruit decrease from 1.0 g/cc for green stage to 0.94 g/cc for ripe stage. The increase in specific gravity was mainly due to increase in dry matter content of fruit. Specific gravity was found to be high initially and then fell gradually. However, the fall in specific gravity during after harvest was mainly due to loss in weight without corresponding decrease in volume. The volume of fruit was recorded to be 192 cc.

The percent rind and fibres content was comparatively less in ripened fruit, as cellulosic and hemi cellulosic material converts into soluble solids during ripening while seed percentage did not change significantly. Waste index is slightly higher in case of matured fruits as compare to ripened fruit, because some quantity of flesh remains attached to rind. Edible index of Bael fruit in terms of flesh or pulp of matured and ripened fruit are 39.54 percent and 55.32 percent respectively. The higher values of edible index of ripened fruits makes the fruits suitable for preparation of different commercial value-added products.

Table 1: Physical parameter of Bael fruit

Sr. No.	Parameter	Value
1	Fruit Colour	Greenish yellow
2	Fruit Shape	Roundish oval
3	Average weight(g)	210
4	Average length (cm)	9.3
5	Average diameter (cm)	6.4
6	Specific gravity(g/cc)	0.94
7	Volume (CC)	192
8	Edible index (%)	55.43
9	Thickness of rind (mm)	4.3
10	Rind (%)	22.83
11	Number of seeds per fruit	88
12	Seed (%)	3.31
13	Waste index (%)	44.57

Bael fruit pulp were analysed for TSS, pH, total acidity, reducing sugar, moisture content, fat, protein, and ash. The results are presented in table 2. Chemical characteristics of Bael flesh there was an alteration in the chemical constituents of the fruit from matured green to ripened fruits. Titratable acidity, pH and crude fibre reduced during ripening. While TSS, moisture, fat, ascorbic acid, reducing and total sugar increased during ripening. Total soluble solids increase significantly from matured stage (8.3^0Bx) to ripened stage (18^0Bx). The value tremendously increased with increase in maturity stage. The final sugar content in ripe fruits was more than twice. The increase in parameter may be attributed to the accumulation of hydrolysed starch. Moisture increases during matured stage due to hydrolyzation of cellulosic and pectic material. Fat was negligible in Bael fruit pulp. Crude fibre decreases with maturity due to reaction with starch. The sugar- acid ratio increased gradually with maturity. A more sugar -acid ratio of fruit sweetens the pulp and makes it palatable. Gradual increase in dry matter, TSS, and total sugar contents with increase in maturity. Ascorbic acid, tannin and marmelosin contents increased with maturity.

Table 2: Chemical composition of Bael fruit

Sr. No.	Parameter	Observation
1	Moisture (%)	62.04
2	Fat	0.39
3	Protein	1.57
4	Ash	1.7
4	Crude fibre	3.07
5	pH	4.2
6	Acidity (%)	0.43
7	Ascorbic acid (mg/100 g)	16.80
8	TSS	18
9	Reducing sugar (%)	5.19
10	Total sugar (%)	15.76

Conclusion

In the present investigation efforts were made for analysis of physicochemical characteristics of Bael fruit. The 100 g of edible Bael fruit pulp contain62.04 g water, 0.39 g fat, 1.57 g crude protein, 3.07 g crude fiber, ash 1.7g. The ascorbic acid content 16.80 mg/100 g fruit pulp make good choice to be use as vitamin C source. The physical characteristics of fruit play a very important role in development of processing technology and on the quality of final products and chemical composition which is assess the nutritional value.

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