Post Harvest Management of Bael Fruit: A Review

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Authors’ contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The bael tree is very hardy and can grow under adverse agro-climatic conditions; unlike other delicate fruit trees. The postharvest system for these fruits is not yet adequately developed, and therefore several handling problems are still common. Bael is a seasonal fruit. Spoilage of bael fruit is mainly due to fungal attack. The stem end of the fruit is very vulnerable to infection. The fruit is presently underutilized but has an important role to play in satisfying the demand for nutritious and delicious natural foods of high therapeutic value. This fruit is rich in antioxidants and phytochemicals besides some essential nutrient components like vitamins, minerals and dietary fibres etc. No other fruit has such a high content of riboflavin. There is need for processing of bael in to different value added products to reduce the post harvest losses. This paper reviews the literature on post harvest management of bael fruit most notably it covers various facets of post harvest processing, different fruit varieties and its features, handling operations and processed products of bael fruit.

Keywords: Bael; processing; handling; nutrition.
1. INTRODUCTION

Bael fruit (Aegle marmelos Correa) has been known in India since ancient times, and the tree on which it grows is regarded as sacred [14]. This fruit is mentioned in Vedic times and also in early Hindu, Buddhist and Jain literature [7]. Bael is a subtropical and deciduous tree, which is very hardy and can thrive well under diverse agro-climatic conditions. This fruit is an indigenous fruit of India [13]. The plant belongs to the family Rutaceae. Bael is grown in neighbouring countries namely Nepal, Sri Lanka, Bangladesh, Myanmar, Thailand and most of south East Asian countries. In India it is distributed throughout the country, but concentrated area under bael is in eastern parts of the Gangetic plains and nearby areas particularly in Uttar Pradesh, Bihar, West Bengal and Orissa. Its trees are also available in wild state in sub Himalayan tract from Rajasthan to West Bengal, Central and southern India. In Gujarat, bael trees are found growing naturally in the forest with the great diversity. Apart from systematic orchards, bael trees are also planted in nutritional gardens, parks, temple gardens and roadsides for various purposes [11]. The ripe fruits are used for preparation of high quality soft drink and beverages. It has very cooling and soothing effect and also protects the body system for maintaining of temperature during hot summer. The mature fruit is used for preparation of murrabba, candy, toffee and bael powder. The fruit is rich in Vitamin B (Riboflavin) and also has fair amount of Vitamin ‘A’, Vitamin ‘C’ and minerals such as calcium, phosphorus, potassium and protein content in ripe fruit is also very high [12].

Though this fruit is native to India, it is not popular such as other summer fruits, but a lot of people do seek it out solely because of its nutritional properties. It is an acquired taste but definitely worth the effort. Now as many underutilized forest fruits, in tropical regions, are becoming better known and are finding their way in to commercial marketing channels, nonetheless, better technical and scientific knowledge is needed to sustain and enhance the development of these species in appropriate regions. A number of varieties and hybrids have been developed and released in India for commercial cultivation described in Table 1 [11].

2. HARVESTING OPERATIONS

Bael fruits are likely to be damaged if proper care is not taken during harvesting. At the time of harvest, the tree is in a leafless condition and the fruits are completely exposed as shown in Fig. 1(b). The fruits should be picked individually from the tree and should not be allowed to drop to the ground, as even a minor crack in the shell can lead to spoilage during transport and storage [12]. Harvesting by shaking the tree is discouraged since the fruits are likely to develop cracks on impact, as the peel is highly brittle. This fruit should be harvested with a small portion of stalk attached, since it is firmly attached in unripe fruits and provides a useful signal for ripening. On ripening, the attachment of the stalk on the fruit loosens and it can be detached without any effort. The stem end of the fruit, once the stem is detached, becomes vulnerable to infection [11,14].

![Fig. 1. (a) Bael tree branches with fruits before maturing stage (b) Defoliated bael tree with mature fruits exposed stage (April, 2019)](image-url)
Table 1. Bael varieties in India

| Name of variety | Salient Features |
|-----------------|------------------|
| NB-5            | Prolific bearer and fruits are medium in size, round with thin skull, low fibre and seed content. 33° Brix TSS in pulp, mucilage have 48° brix. Major grown areas are Uttar Pradesh, Rajasthan, Bihar, Jharkhand, Uttarakhand. |
| NB-7            | Fruits are very large in size, flattened round, yellowish green in colour. 30° Brix TSS in pulp, mucilage have 42° brix. Majorly grown in Uttar Pradesh. |
| NB-9            | Prolific bearing, fruits are medium to large size with oblong in shape, low fibre and seed content. 38° Brix TSS in pulp, mucilage have 41° brix. Major grown areas are Uttar Pradesh, Rajasthan, Bihar, Jharkhand, Uttarakhand. |
| NB-16           | Fruits are elliptical round, pulpy yellow, average weight 1.3 kg, T.S.S. 31%, and low fibre content. Majorly grown in Uttar Pradesh. |
| NB-17           | Fruits are attractive, average weight 1.75 kg, fibre content low. Majorly grown in Uttar Pradesh. |
| CISH B-1        | It is a early maturing variety. The fruits are medium in size (16.5 cm x 12.0 cm), oval-oblong, with smooth surface, yellow at maturity, low in mucilage and fibrous, high seed content. 32° Brix TSS in pulp, mucilage have 43° brix. Major grown areas are Uttar Pradesh, Rajasthan, Bihar, Jharkhand, Uttarakhand. |
| CISH B-2        | The fruits are medium in size (16.0 cm x 14.0 cm), yellow at maturity, low in mucilage and fibrous, low seed content. 31° Brix TSS in pulp, mucilage have 38° brix. Major grown areas are Uttar Pradesh, Rajasthan, Bihar, Jharkhand, Uttarakhand. |
| Goma Yashi      | Good quality fruits with large in size. Oval in shape, greenish yellow in colour. 35-39° Brix TSS in pulp, mucilage have 41-43° brix. Major grown areas are Rajasthan and Gujarat. |
| Plant Aparna    | Dwarf tree with drooping foliage, almost thornless, heavy bearer. Fruits average weight 1.0 kg, 34° Brix TSS in pulp, mucilage have 47° brix. Major grown areas are Uttar Pradesh and Uttarakhand. |
| Plant Shivani   | It is an early mid season variety. Fruit weight varied from 2 to 2.5 kg, 36° Brix TSS in pulp, mucilage have 48° brix. Major grown areas are Uttar Pradesh and Uttarakhand. |
| Plant Sujata    | Trees are medium dwarf, heavy bearer. Fruit weight varied from 1 to 1.5 kg. 32° Brix TSS in pulp, mucilage have 42° brix. Major grown areas are Uttar Pradesh and Uttarakhand. |
| Pusa           | It is mid season variety. Fruits are ovoid, oblong. The fruit weight range from 1.5 to 2.5 kg. 33° Brix TSS in pulp, mucilage have 41° brix. Major grown areas are Uttar Pradesh and Uttarakhand. |
| Urvashi        | Brix TSS in pulp, mucilage have 41° brix. Major grown areas are Uttar Pradesh and Uttarakhand. |

3. GRADING, PACKAGING, TRANSPORTATION AND STORAGE

Bael fruits have different shape and size; hence they should be graded accordingly. There is no recommended practice for packing bael fruits. In India, the fruits are packed in gunny bags, sacks, baskets, or wooden crates and sometimes they are transported in bulk loads without any packing. It is highly desirable that some cushioning material, such as straw, shredded paper or leaves, be used when packing bael fruits. Development of cracks due to impact during packing, transportation and marketing of fruits has to be avoided, or heavy fungal infection will take place [12] [14].

Bael fruit itself has a fairly good storage life compared to other tropical fruits, but unfortunately very little information is available in the literature on storing bael fruits. The only information available is on the application of cool storage to enhance the storage life of bael fruit [8]. The storage life of bael fruits could be increased from two weeks at ambient temperature (27 to 33°C) to 12 weeks at a cool storage temperature of 9°C. Marked physiological breakdown is noticed when the storage temperature is below 9°C, indicating that bael fruits are chilling-sensitive. Spoilage of bael fruit is mainly due to fungal attack. The stem end of the fruit is very vulnerable to infection [11,12].

4. NUTRITION VALUE

The fibrous yellow pulp of bael fruit has aromatic nature. The pulp of the bael fruit contains many functional and bioactive compounds namely carotenoids, phenolics, alkaloids, coumarins, flavonoids, terpenoids and other antioxidants which may protect against chronic diseases [3] [13]. It is highly nutritive with the richest source of riboflavin. It is richer than most of the reputed fruits like apple, guava and mango as the calorific value of bael, apple, guava and mango are 88, 64, 59 and 36 calories respectively per 100 g [9]. Bael fruit is a highly nutritious. It has unapped source of nutritive values. Table 2 shows nutritional composition of bael fruit.

No other fruit has such a high content of riboflavin. Marmelosin (C_{15}H_{12}O_5) is the most...
Table 2. Nutritive values of bael fruit (per 100 g of edible fruit pulp) [6]

| Nutrients       | Values (quantities) |
|-----------------|---------------------|
| moisture        | 61.5 g              |
| Carbohydrates   | 31.80 g             |
| Fibre           | 2.90 g              |
| Protein         | 1.80 g              |
| Minerals        | 1.70 g              |
| Fat             | 0.39 g              |
| Ascorbic acid   | 65-100 mg           |
| Calcium         | 85.00 mg            |
| Iron            | 0.60 mg             |
| Carotene        | 55.00 mg            |
| Niacin          | 1.1 mg              |
| Thiamine        | 0.13 mg             |
| Riboflavin      | 0.03 mg             |
| Acidity         | 0.25-0.36%          |
| Viscosity       | 12.7-19.0%          |

important, therapeutically active principle of bael fruit. It is isolated as a colourless crystalline compound [2]. Medicinal properties of bael fruit are described and concluded that the ripe fruit is a tonic, a restorative, an astringent, a laxative, and good for the heart and brain [5]. The unripe fruit is regarded as astringent, digestive and stomachic and is prescribed to treat diarrhoea and dysentery. Bael is nutritious and can form an important dietary supplement [1]. Compared to orange and grapefruit, bael fruit contains about three times the total soluble solids (TSS) and at least 1.5 times as many calories. The essential and non-essential amino acid contents of bael compare favourably with those in the citrus fruits. Zinc, chlorine and sodium concentrations were also higher in bael [11].

5. PROCESSING

5.1 Pulp Extraction

Extracting pulp from the ripe bael fruit presents the main hindrance to processing [14]. Traditionally the pulp extraction is carried out by striking fruits against hard surface and then the fruit hard pericarp (skull) broken in two halves and later scooping out the pulp with stainless steel spoon or knife. Water is added to the extracted pulp (with seeds and fibre) while kneading. The best results are obtained by adding water equal to the amount of the pulp (with seeds and fibre). The pulp extraction process is same for all value added products. The flow chart for common extraction of bael fruit pulp is shown in Fig. 2. After extracting the pulp different value addition processes are mentioned below for different value added products. The flow charts for bael value added products squash, powder, fruit leather, jam are shown in Figs. 3,4,5,6 respectively.

5.2 Domestic Level Usage

Fruits are not eaten fresh because of their astringency and the mucilaginous nature of pulp, but they are widely consumed in processed form all over India. A very refreshing beverage (sherbet) is prepared from bael pulp simply by mixing it in water, straining the seeds and then adding sugar, salt, according to taste. This beverage is considered to be very healthy, especially for the digestive system. To save people the hassle of mixing, it is also available in the market as bael squash which can be used after diluting with water.

5.3 Potential Processed Products

As the storage quality of the whole fruit cannot be maintained for long period of time, improvement in the post harvest processing will enhance the effective utilization of the fruit [10]. Because of its hard shell, mucilaginous texture and numerous seeds, it is not popular as a fresh fruit. The fruit has excellent aroma which is not destroyed even during processing. Therefore, there is tremendous potential for processing this fruit into various products. It is usually processed into products refreshing beverages, powder, leather, jam. These products being highly nutritive and therapeutically important can be very easily popularized in internal as well as international markets [4] [10]. The flow diagrams of process preparation of refreshing beverages/squash, powder, leather, jam are shown in Figs. 3,4,5,6 respectively [9,11].
Fruits (mature, ripe)
  ↓
Washing
  ↓
Breaking
  ↓
Scooping of pulp
  ↓
removal of seeds and fibre
  ↓
Addition of water to fruit pulp (if required)
  ↓
Addition of citric acid
  ↓
Kneading
  ↓
Heated up to 80°C
  ↓
Strained the fruit pulp with stainless steel sieve
  ↓
Bael fruit pulp

**Fig. 2. Flow chart for process preparation of Bael fruit pulp extraction**

Bael fruit pulp
  ↓
Addition of citric acid and Preservatives (Potassium meta bisulphite) in water (if needed)
  ↓
Filter and add
  ↓
Prepare syrup by mixing 1.4 water and 1.6 kg sugar per kg of pulp
  ↓
Mixing
  ↓
Pour in to bottles and seal
  ↓
Heat pasteurize in bottles at 80-95°C
  ↓
Cool in cold water

**Fig. 3. Flow chart for process preparation of Bael fruit squash**

Bael fruit pulp
  ↓
Addition of SO₂ / (1g KMS per kg of pulp)
  ↓
Traying
  ↓
Drying at 55-60°C for 17-18 hours to a moisture content of 10%
  ↓
cutting
  ↓
Further drying at 55-60°C for 9-10 hours to a moisture content below 4%
  ↓
Grinding
  ↓
Packaging

**Fig. 4. Flow chart for process preparation of Bael fruit powder**
6. CONCLUSION

Many underutilized fruits have a great potential for an expanded worldwide market for fresh fruit consumption and industrially processed products. Bael fruit is one of the most nutritious fruits of India, and its medicinal properties have long been known. Investigations have clearly indicated that a number of acceptable processed products can be prepared from bael fruit. Methods have been standardized, and storage requirements have also been formulated to enable commercial utilization of this fruit and its processed products. A lack of processing machineries is the main hindrance for promoting bael fruit consumption. The main problem is lack of market awareness, as to date there has been no serious effort regarding the marketing and export of processed products of bael fruit. The present paper on bael fruit post harvest processing will serve to bring attention to this nutritious fruit, as yet unknown in the world market, and help to create awareness and increased interest in the commercial development of processed bael fruit products.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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