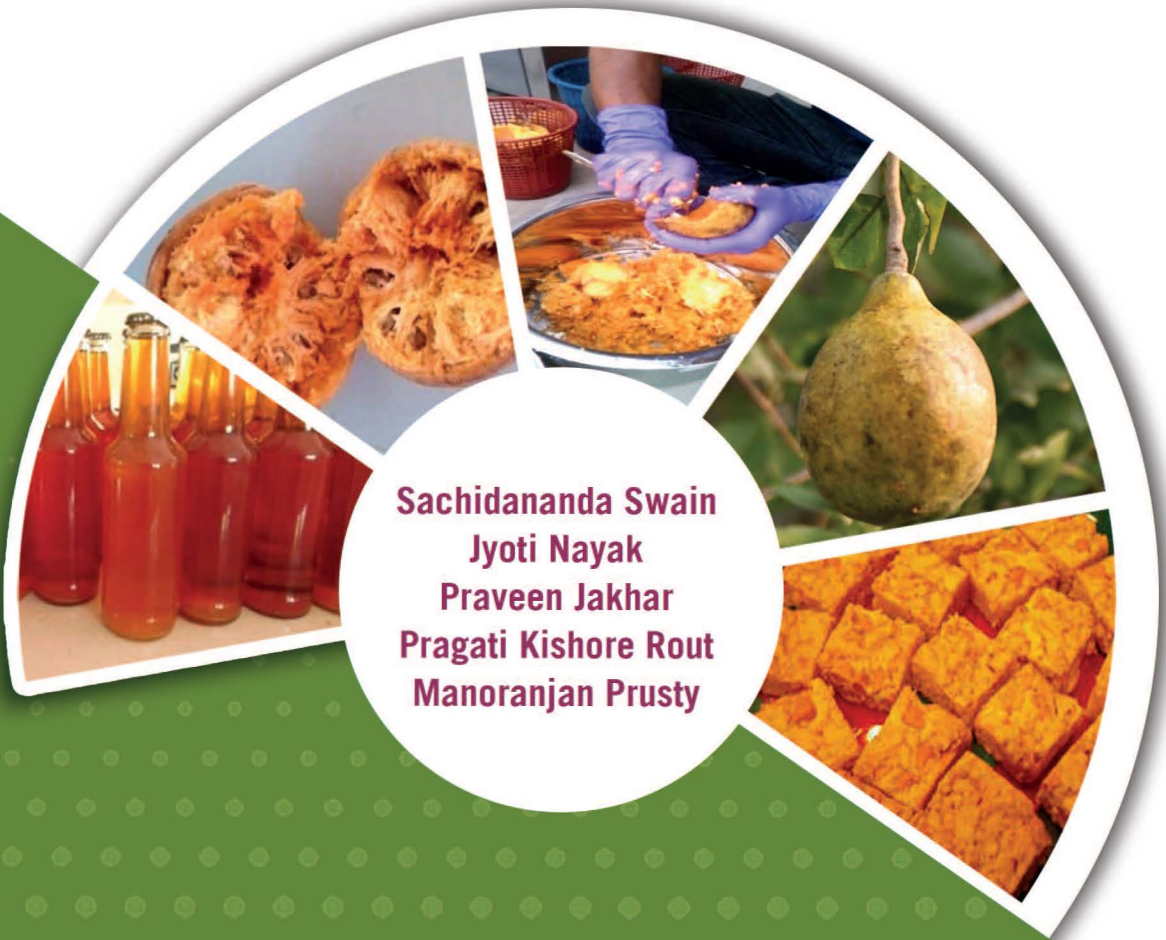


Augmenting income of farm women through value addition in Bael (*Aegle marmelos* L.)



Sachidananda Swain
Jyoti Nayak
Praveen Jakhar
Pragati Kishore Rout
Manoranjan Prusty



भा.कृ.अनु.प. -केन्द्रीय कृषिरत महिला संस्थान
(भारतीय कृषि अनुसंधान परिषद)

भुवनेश्वर - 751 003, ओडिशा, भारत

ICAR- CENTRAL INSTITUTE FOR WOMEN IN AGRICULTURE

(Indian Council of Agricultural Research)

Bhubaneswar - 751 003, Odisha, India



Augmenting income of farm women through value addition in Bael (*Aegle marmelos* L.)

Sachidananda Swain

Jyoti Nayak

Praveen Jakhar

Pragati Kishore Rout

Manoranjan Prusty



भा.कृ.अनु.प. -केन्द्रीय कृषिरत महिला संस्थान

(भारतीय कृषि अनुसंधान परिषद)

भुवनेश्वर - 751 003, ओडिशा, भारत

ICAR- CENTRAL INSTITUTE FOR WOMEN IN AGRICULTURE

(Indian Council of Agricultural Research)

Bhubaneswar - 751 003, Odisha, India



Title

Augmenting income of farm women through value addition in Bael (*Aegle marmelos L.*)

Authors

Dr. Sachidananda Swain

Dr. (Mrs) Jyoti Nayak

Dr. Praveen Jakhar

Er. P. K. Rout

Mr. M. Prusty

Citation

Swain, S., Nayak, J., Jakhar, P., Rout, P. K., Prusty, M. 2021. **Augmenting income of farm women through value addition in Bael (*Aegle marmelos L.*)**. Technical Bulletin no. 43, ICAR-CIWA, Bhubaneswar, Odisha. pp 28

Published by

Dr. Anil Kumar

Director, ICAR-Central Institute for Women in Agriculture

Plot No. 50-51, Mouza-Jokalandi, Post-Baramunda,

Bhubaneswar - 751003, Odisha, INDIA

Copyright

© All rights received, ICAR-Central Institute for Women in Agriculture. 2021

ISBN: 978-81-951308-9-4

Printed at:

M/s Semaphore Technologies Pvt. Ltd.

3 Gokul Baral Street

Kolkata-700012

Preface

Rural women's economic and social empowerment is necessary for overall economic development of society and nation. Rural women are now increasingly running their own business yet their entrepreneurial potential, managerial skill and socio-economic contribution remain largely neglected. Women entrepreneurship development is the instrument of women empowerment. Women's entrepreneurship is important for women's position in society, and their economic development will lead to development of family, community and country. Empowerment through entrepreneurship leads to self-sufficient and makes women aware about their status, existence, rights and their position in the society. Women entrepreneurship is gaining importance in India in the wake of globalization and economic liberalization. The institutional policy framework of ICAR-CIWA for developing entrepreneurial skills, providing vocational education and training has widened the horizon for economic development of women. Women entrepreneurs tend to be highly motivated, self disciplined & self directed. On the other hand, empowerment of rural women makes society foundation strong from grassroots. Economic empowerment of rural women will lead to the development of our country thus it is very necessary to give keen attention on this aspect. Food security interventions often focus on improving food production and food security at the community and household level. Thus, improving the status of women within the household and at the community level will deliver significant improvements to agricultural production, food security, child nutrition, health and education. Agro-industry and high value-added agricultural sectors are proposed as the key sectors to improve inequality issues, smoother employment transformation, generate high growth and induce high output production. Agricultural production and processing sectors have better potential to generate more income at households level simultaneously addressing gender inequality issue creates better income distribution and to induce more savings.

The ICAR-Central Institute for Women in Agriculture (ICAR-CIWA), Bhubaneswar carries out action research programmes in various aspects related to women empowerment in agriculture. For dissemination of technologies for stakeholders' the present bulletin will be an important link for enhancing the knowledge and skills of farmwomen to develop value added product from Bael (*Aegle marmelos L*).

Authors



Sl. No	Contents	Page No
	Preface	
1.	Introduction	1-5
	1.1. Harvesting	
	1.2. Effect of mineral nutrients on control of fruit drop	
	1.3. Fruit cultivars	
	1.4. Chemical composition of bael fruit	
	1.5. Packaging and storing of fresh fruits	
2.	Post harvest disorders & Management	6-8
	2.1. Fruit cracking	
	2.2. Fruit rot	
	2.3. High and low temperatures	
	2.4. Pathological disorders	
	2.5. Pest Management	
3.	Bael products and uses	9-14
	3.1. Bael Preserve and candy	
	3.2. Bael Fruit Squash	
	3.3. Bael pulp	
	3.4. Dehydrated Bael	
	3.5. Bael Ready-to-serve (Bael RTS)	
	3.6. Bael Powder	
	3.7. Bael Jam	
	3.8. Bael Slab	
	3.9. Bael Toffee	
	3.10. Bael Wine	
	3.11. Bael Panjiri	
	3.12. Flavoured bael products	
	3.13. Non-edible Uses	
	3.14. Other uses of Bael	
	3.15. Utilization of processing waste of bael	
4.	Economic analysis	15
5.	Summary	16-17
6.	Annexure	18-36



1. INTRODUCTION

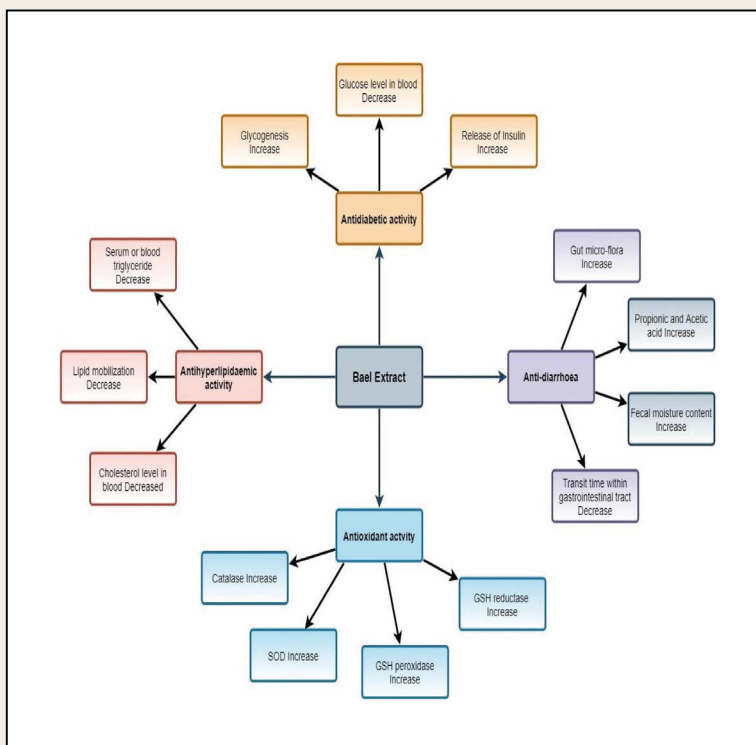
Bael (*Aegle marmelos L.*) is one of the most important minor fruit crops with medicinal and antioxidant properties grown in sub-tropical India, belonging to the family Rutaceae. It is commonly known as Bengal quince, Indian quince, Golden apple, Holy fruit, Bel, Belwa, Sriphal, Stone apple/wood apple and Maredo in India. Bael fruits are very hardy and mature after 10-11 months from fruit set. The fruit is globose with grey or yellowish hard woody shell. The pulp is brown, mealy, odorous, resinous, acid or sweetish with numerous seeds scattered through it. Its medicinal properties have been described in the ancient medical treatise in Sanskrit, *Charaka Samhita*. All parts of this tree (stem, bark, root, leaves and fruit at all stages of maturity) have medicinal virtues and have been used as medicine since time immemorial.

Bael contains appreciable amount of minerals like Ca, Mg, Fe and other elements which are very important for human health. Fruit development stages (FDS) are associated with significant changes in carbohydrates, sugars and poly-phenol content. The mature bael pulp contains carotene and vitamins. Protein and secondary metabolites (poly-phenol) also changes during fruit development stage up to November (green stage). It is useful in the treatment of diabetic patients due to high contents of mucilage and secondary metabolites as caumarin and marmelosin. The fruit is much used in India as a liver and cardiac tonic and when unripe, as a means of halting diarrhoea and dysentery and for effective treatment for hiccup, sore throat and disease of the gums. It is mildly astringent and used to cure dysentery, diarrhoea, hepatitis, tuberculosis, dyspepsia and is good for heart and brain (Sharma *et al.*, 2010). Roots have antidiarrhoeic, antidote to snake venom, anti-inflammatory and wound healing properties. The fruit's medicinal value is very high when it just begins to ripe. The ripe fruits are sweet, aromatic, cooling, laxative, good tonic for heart and brain and cure dyspepsia. Bael has a high tannin content which makes it an effective cure for dysentery and cholera. Bael is considered to be one of the richest sources of riboflavin and provides lots of minerals and vitamins when added to diet. Another interesting point about bael is the fact that it is equally useful while still unripe, whereas other fruits become consumable on ripening. Bael fruit comes under the underutilized fruits, because, it's neither grown commercially on large scale nor traded widely. It is cultivated, traded and consumed locally.

Bael is a climacteric fruit, taking about 11 months to ripen on the tree. Its ripening can be advanced by 45 days with pre-harvest treatment of ethephon (1000 ppm) during nine months after fruit set.

Women produce more than 50 percent of the food grown worldwide. In addition to the time-consuming tasks of grinding and pounding the staple grains, women process and preserve the fruit and vegetable produce from their home gardens and from the forests. Moreover, women are almost universally responsible for preparing food for their households and thus for the nutritional well-being of its members. Usually, women's representation is greater in allied agriculture than in grain production, and poor households require the greater involvement of women in income-

generating activities than financially stable ones. While they also perform the overwhelming majority of the work in food processing in developing countries. Food processing contributes to food security through reducing food losses, contributing to diversity of diet and supplying important vitamins and minerals. At present, the losses in horticulture crops range from 15 to 25 percent from harvesting to marketing. Moreover, during the peak season there remains glut of horticulture produce and selling of the produce becomes difficult. There is need to design programmes which could gainfully utilize the services and skills of women in relation to their involvement in agri-based allied activities. This would also help in generating self-employment and rural entrepreneurship. Some of the ventures include value addition to fruits and vegetables, food processing, food preservation and testing units; post-harvest management units. Entrepreneurship skills can help in building confidence and self-awareness through income generation. Various activities can be taken up by rural women for income generation while being at home and by organizing themselves in Self Help Groups (SHGs). Therefore, to enhance the income level and living standard of those farming families there is an urgent need to provide their family members particularly women an occupation based training like preservation of seasonal fruits and vegetables, which not only provides them an occupation but also develop entrepreneurial skill amongst them.



Mechanism of antioxidant, anti-diarrhoea, antihyperlipidemic and anti-diabetic activities of bael (SOD: super oxide dismutase, GSH: glutathione). (Source: Sarkar *et al.*, 2020)



1.1 Harvesting

Bael fruits are likely to get damaged if proper care is not taken during harvesting. Mature fruits are harvested individually from the tree along with the portion of fruit stalk (2-3 cm) to avoid infection and it also help to judge maturity. The fruit is tested for maturity by dropping onto a hard surface from a height of 1ft (30 cm). Immature fruits bounce, while mature fruits do not. After harvest, the fruits are kept in the sun for 2 weeks to fully ripen. Budded plants come to bearing 3-4 years after planting. But to reach optimum productivity it will take about 10 years. The crop flowers in February to May depending on the climatic conditions of the locality and fruits will be available from July to December depending on the flowering month. A well grown tree will give 200-250 fruits/year.

1.2 Effect of mineral nutrients on control of fruit drop

Boron promotes absorption and metabolism of sugars and helps in synthesis of pectic substances for the cell wall of actively elongated pollen tubes indicating that boric acid plays an important role in wall structure of the tube membrane. Boron is also known to improve stigma receptivity thus resulting in better pollination and fruit set. Among the different sprays of mineral nutrients, borax 1.0% is found effective and resulted in minimum fruit drop and maximum fruit retention. Similar results have been reported in Bael (Saini *et al.*, 2004). Reduction in fruit drop by sprays of mineral nutrients may be due to a better availability of nutrient and growth regulators particularly the auxins which play an important role in fruit growth and development. Improvement in fruit retention percentage due to spray of micronutrients might be attributed to reduction in fruit drop. Boron spraying increased cell division, cell enlargement as well as the biosynthesis of carbohydrates and proteins which causes increase in pulp weight. Significant differences are observed for fruit fibre, mucilage and non-edible portion of fruit by application of mineral nutrient during both the years of experiment.

1.3 Fruit cultivars

There are no standardized names for *Aegle marmelos* cultivar. They are given names on the basis of locality where these are found. Fruits of different cultivars are of different shapes and sizes, such as spherical, oblong, cylindrical, pear-shaped and flat. Fruit weight also varies in different cultivars. The percentages of peel, seeds and contents of other fibres also varied. There are reports available on the cultivars of Bael mainly from Uttar Pradesh and Bihar states of India. Around twelve cultivars, viz., Basti No.1, Gonda No.1, 2 and 3, Kagzi Etawah, Sewan Large, Deoria Large, Chakaiya, Lamba, and Baghel has been reported. Kagzi Etawah, Sewan Large, Deoria Large and Mirzapuri have been found to be superior and better than the other varieties in case of taste and qualities. Four cultivars viz., Narendra Bael-4, Narendra Bael-5, Narendra Bael-7, Narendra Bael-9, Narendra Bael-16 and Narendra Bael-17 have been identified and studied by Srivastava and Singh (2004). They experimented to evaluate these commercially important cultivars and found that the heaviest fruit weight was recorded in 'Narendra Bael-7', whereas minimum fruit weight, fruit length and fruit breadth recorded is of 'Narendra Bael-4'. Fibre content



and seed/fruit are recorded minimum in ‘Narendra Bael-9’ and maximum in ‘Narendra Bael-5’. Maximum total soluble solid, ascorbic acid and total sugar content is found in ‘Narendra Bael-5’. Though, minimum total soluble solids, ascorbic acid and total sugars are recorded in ‘Narendra Bael-7’. A number of cultivars have been selected recently which are the best among the others with regards to yield and fruit quality. Narendra Bael-5 and 9 are popular among the farmers of Uttar Pradesh. These are;

‘NB 5’-Fruit size is medium, round in shape having smooth surface at maturity, low mucilage, moderately fibrous and has soft flesh with excellent taste.

‘NB 6’-Fruit size is medium, round with smooth surface, and has thin rind, few seeds, soft flesh, low mucilage and mild acidic.

‘NB 16’- Elliptical round, pulp yellow, Avg. weight 1.3 kg, TSS 31%, medium seed and low fibre content.

‘NB 17’- Fruits oblong, big sized, fruit quality excellent, seed content less.

‘Pant Shivani’-Mid season cultivar with ovoid oblong shape, size 2 kg, colour lemon yellow on ripening, fiber and mucilage content medium, rind medium thick, pulp light yellow with very good taste and pleasant flavour (Singh *et al.*, 2000).

‘Pant Bael-10’-This variety is found giving maximum yield. ‘Pant Aparna’-late cultivar with small fruit size (0.6 - 0.8 kg), globuse shape, and seed, mucilage, fibre and acidity are low. Its Flesh is yellow, sweet, tasty and having good flavor.

‘Pant Urvashi’- Best on yield and yield characteristics. Macronutrient content of leaves among four varieties of Bael viz. Pant Aparna, Pant Shivani, Pant Sujata and Pant Urvashi does not differ significantly except the calcium content of leaves which shows significant difference among four varieties during both the year of experiment. Maximum calcium content of leaves is observed in Pant Aparna and minimum calcium content of leaves is estimated in Pant Urvashi. The average nitrogen, phosphorus, potassium, calcium and magnesium content of leaves are 0.88-0.98%, 0.29-0.35%, 1.02-1.19%, 1.29- 1.82% and 0.34-0.42% respectively. The mean levels of the macronutrient in leaves are found optimum in all the varieties in comparison to the critical limit of macronutrient in Bael as calculated on dry weight basis.

1.4 Chemical composition of bael fruit

The chemical composition of bael fruit is influenced by environmental factors. The chemical composition of fresh fruit is shown in Table 1. Bael fruit (Fig. 1) contains 18-29 % of total soluble solids (TSS) having acidity level of 0.32 % citric acid equivalent. In addition, it is rich in vitamin A (186 IU/100g pulp) and other volatile oils. Its food value is 137 kCal/100g. Thus, it is richer than most of the reputed fruits like apple, guava and mango which have a calorific value of 64, 59 and 36 only.



Fig. 1: Bael fruit



Table 1. Nutritional composition of Bael fruit

Component	Value (per100g)
Moisture (%)	62-64
Protein	1.8±0.12 g
Fat	0.4±0.06 g
Mineral	1.9 ±0.02 g
Fibre	6.9 ± 0.11 g
Carbohydrate	31.1 ± 1.4 g
Iron	8 ±0.09 g
Vit-A (IU)	186 ±10.8
Vit-B1	0.13 ± 0.02 g
Vit-C	8-19 mg
Potassium	600 mg
Phosphorous	50 mg
Calcium	85 mg
Calorific value	134 kCal

1.5 Packaging and storing of fresh fruits

Storage life of bael fruits depends on the stage of harvesting. Remove immature and injured fruits. Grade the remaining fruits according to their size. There is no standard practice for the grading of bael fruits. Wash fruits using chlorinated water (100 ppm) and drain them. Fruits are packed in gunny bags, baskets or wooden crates for transportation, storage and marketing. Use cushioning material, such as straw or paper, when packing bael fruits.

- Fruits harvested at full maturity (light green colour) can be kept for about 15 days at 30°C.
- Fruits harvested ripe can be stored for only one week at 30°C.
- In cold storage, they can be stored for about 3 months at 9°C and 85-90% relative humidity.

Care should be taken that fruits should not develop any cracks while packing, transportation and marketing otherwise it will get spoiled due to fungal infection. The ripe bael fruit could be made available 2-3 months prior to schedule with the treatment of ethrel and storing the fruits at 30°C after harvesting in January. It takes 18-24 days for the fruit to be artificially ripened. The composition of fruits ripened artificially or naturally, did not vary much though they have with slight less sugar.

- Fruits may be wrapped with blue cellophane paper, butter paper, perforated polyethylene bagging + KMnO₄ and perforated polyethylene bagging for the extension of shelf life of 24 days over other treatments.
- Among the chemicals by which fruits are treated, NAA 100 ppm, GA3 50 ppm, stannous chloride 250 ppm and cobalt nitrate 250 ppm are effective in extension of storage life and marketability of the fruits.

2. Post harvest physiological disorders and Management

2. Post harvest physiological disorders

2.1 Fruit cracking

During the traditional method of harvesting the bael fruits falls on the hard ground surface directly, which leads to breakage or crack of the fruit. This leads to the infestation of the microorganisms. The cracking can be minimized by maintaining optimum soil moisture regime and by provision of winds breaks against hot desiccating wind side of orchard. Fruit cracking has been observed as a major physiological disorder and its degree of damage depends according to genotypes / varieties and locality also.



Fig. 2: Bael dropping at the ground

2.2 Fruit rot

Internal rotting of fruit is a serious problem. It is mainly caused by damage to fruit during harvesting, storage and transportation or non-maintenance of proper ventilation during storage. Avoid storage in enclosures especially in polythene. Such disease problem can be avoided by harvesting of fully mature fruits and also to avoid damage to the fruit and wrapped / stored with news paper or phenol papers. Internal rotting of fruit is serious problem, which is mainly caused by the damage to fruits during the harvesting, storage and transportation or not maintaining proper ventilation during the storage of the harvested fruit.



Fig. 3: Post harvest loss due to ineffective storage of bael fruit

2.3 High and low temperatures

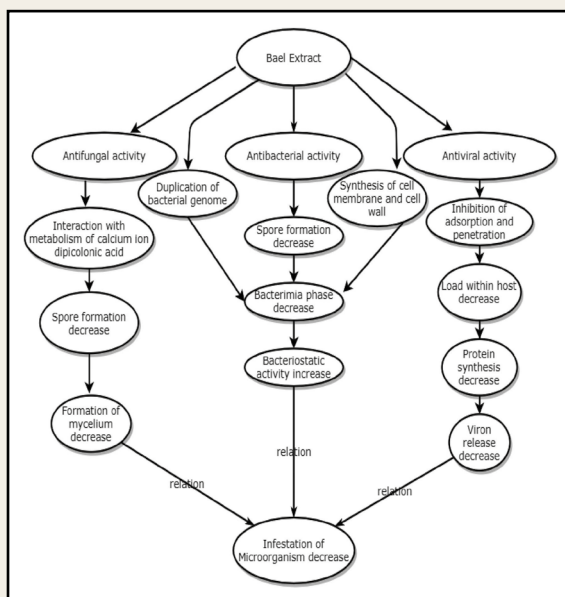
The type of spoilage observed in bael fruit at higher temperature is quite different from that of low temperature storage. At high temperature (above 14°C), brown to black patches appear on the surface of the fruit together with heavy fungal growth inside the fruit, which indicates fungal spoilage. In case of low temperature storage (below 9°C), spoilage is caused mainly due to chilling injury *i.e* appearance of brown spot on the bael surface which gradually increase in number, size and colour intensity indicating chilling injury, with symptoms similar to those found in other citrus fruits. At high temperature, fungus and mould is likely to develop at the stem end and at any cracks in the rind. During storage, an increase in total sugar and reduction of reducing sugar is observed.



2.4 Pathological disorders: pest management

Bael fruit borer and fruit fly incidence are associated with ovipositor on smooth green surfaces of fruits when poly-phenol content of the fruit decreases between 3-4 months after fruit setting. So, proper post harvest storage is an important aspect in bael where pathogenic infection becomes very serious in some varieties in ambient storage. The fruit borer, *Cryptophlebia ombrodelta* (Lower) (Tortricidae: Lepitoptera) earlier reported as a pest of legumes, macadamia, litchi, and longan fruit from other regions of India has been observed damaging bael (*Aegle marmelos*) as first record on these crops from the eastern region of India. *Cryptophlebia illepida* is recorded to infest bael fruit and growing newly twigs and found to be prevalent during the entire fruiting season from July to April in Jharkhand region.

On hatching, the caterpillar bores into fruit and feed on the pulp leaving behind frass (The biological waste that insects leave behind as a natural by-product of their metabolic activities). Pupal cases are found to attach on infested fruits. The infested fruits rot and even drop off. The keeping quality of infested fruit also reduces down. Fungal growth can take place inside the fruits without showing evidence on the surface. The fungal infection of bael fruit occurs only as a result of cracking of the fruit surface through entry of the stem end. The bacterium *Xanthomonas bilvae* causes bacterial shot hole in bael fruit leaves. The pathogen also infects twigs and thorns and causes fruit canker. A marked physiological breakdown is noticed when stored at temperature below 9°C.



Mechanism of antimicrobial activity of bael

2.5 Management

- Clean cultivation is needed as weed plants serve as alternate hosts.
- Cover the fruit with polythene bags when the fruits are up to 5 cm.
- Use light trap @ 1/ ha to monitor the activity of adults.
- Flowering stage spray NSKE 5% or neem formulations 2 ml/l.
- Apply di-methoate 30 EC 1.5 ml/l.
- Dipping the fruits in lime water for a few minutes just after harvest is a practice done in many parts of India to avoid infection.
- Applying lime over the cut surface of the fruit stalk is also effective to ward off infection in storage.



3. Bael products and uses

Bael products and uses

Various bael products have been developed from different parts of the bael tree. As bael is highly rich in enormous nutrients but being a seasonal fruit utilisation of nutrients may not be available throughout the year, since it is utmost required to make several bael products to get those valuable nutrients available. A large number of bael processed products (Preserve, candy, panjiri, toffee, jam etc.) Some of the processed products are described below.

Pre-processing into pulp

Break the fruits using a strong knife or special bael breaking equipment.

- Scoop out the pulp along with the seeds and fibres and discard the peel (Fig.4).
- Add water equal to weight of pulp (1:1).
- Add 5g citric acid per kg pulp.
- Mix the pulp.
- Heat mixture at 80°C for one minute.
- Pass mixture through a pulping machine or stainless steel sieve of 20 meshes. Discard seeds and fibres.
- Treat pulp with 1000 ppm of SO₂ (optional).
- Dissolve sodium metabisulphite (1.5 g/kg) in some water and add.
- Place pulp in airtight containers and seal.
- Store pulp for up to 6 months for further processing.



Fig. 4: Pulp removal (manually)

3.1 Bael Preserve and candy

Preserve and candy are prepared from mature (tender green fruit), whole or large pieces of fruit in which sugar are impregnated till it becomes tender and transparent. The minimum fruit portion and minimum total soluble solids in preserves (Fig. 5) should be 55 and 70%, respectively. Fruits in general contain more than 75% water and get spoiled quickly if not stored properly. Removal of water from fruits is known to help in longer period of storage. The osmotic dehydration techniques not only enables the storage of fruits for a longer period but also preserve the flavour, colour and texture of the product to a great extent and prevents its microbial spoilage. A fruit of its pieces impregnated with sugar or glucose syrup, subsequently drained free of syrup



Fig. 5: Bael preserve

and dried is known as candied fruit. The total sugar content of the impregnated fruit is kept at about 75% to prevent fermentation. In case of bael candy, the fruit slices are drained subsequently free of syrup and dried at 55-60°C for 8-10 hrs in oven. The method of preparation of bael candy is given in flow chart-1.

3.2 Bael Fruit Squash

An ideal composition of bael fruit squash (Fig. 6) is 50 % extracted pulp, 50° Brix and 1% acidity. The squash is chemically preserved by addition of 300 ppm SO_2 . Fruitbeverages commercially contain at least 25 % fruit pulp or juice and 40-50 % TSS, besides 1% acid. The squash from bael fruit pulp is prepared by adjusting the TSS and by adding the preservatives like sodium metabisulphite @ 350 ppm SO_2 , sodiumbenzoate @ 1g/litre.



Fig. 6: Bael squash

The squash is then filled in sterilized bottles, crowned and pasteurized at 80°C for 30 minutes followed by cooling and wax sealing to insure air tightness. The methods of making bael fruit squash are given in flowchart-2.

3.3 Bael pulp

The ripe fruit are to be washed with tap water and broken by striking against hard object. The fruit pulp along with seeds and fibres is scooped with the help of stainless steel spoon. Amount of water equal to the weight of pulp is added. Then, the mixture of pulp and water is heated to 80°C for 1 minute and cooled. Pulp free from seeds and fibres is then obtained by passing through 20 mesh stainless steel sieve. The extracted bael pulp (Fig. 7) may be improved by adjusting the TSS by addition of sugar and acidity by the addition of citric acid. The method of preparation of bael pulp is given in flow chart -3.



Fig. 7: Bael pulp

3.4 Dehydrated Bael

Select mature green fruits, wash and cut 1-1.5cm thick slices of fruit pulp after removing its hard shell. Fumigate these slices with sulphur dioxide fumes for an hour in sulphur box and dehydrate at 55-60° C in oven up to a constant weight. Pack dried slices in polyethylene bags or glass jar for future use. The method of preparation of dehydrated bael is given in flow chart -4.

3.5 Bael Ready-to-serve (Bael RTS)

For preparing bael ready-to-serve (RTS) drink, TSS (%) and acidity (%) in the extracted bael fruit pulp is to be analyzed. On the basis of analysis, requisite amounts of sugar and



citric acid dissolved in required amount of water are added to measure quantity of bael pulp for adjustment of TSS (%) and acidity (%) in RTS drink (Fig 8) as per treatment. The prepared RTS drink is thoroughly homogenized and filled in clean, sterilized 200 ml capacity glass bottles leaving 2-3 cm head space. For the preparation of “Ready-To-Serve”(RTS) beverage, 15% TSS and 0.29 % TA and preservative (mainly citric acid) is found satisfactory. The beverage filled bottles are sealed with sterilized crown corks, pasteurized in boiling water for half an hour, cooled in air and stored in cool and dry place. The methods of bael RTS are given in flow chart-5.



Fig. 8: RTS Bael

Table 2. Nutritional facts approx value per 100 ml

Parameters	Value
Protein	0.00 g
Carbohydrate	76.35 g
Energy	305.42 kCal
Vitamin C	-
Sodium	21.81 mg
Calcium	5.68 mg
Sugar	71.08 gm
Saturated Fat	-
Trans Fat	-

3.6 Bael Powder

Tender bael powder can be stored for long time, if harvested at 4-8 months after fruit set. Bael powder can be prepared by simply grinding fruit slices in a grinder. Pack ground bael powder in polyethylene bags and store in dry places after proper sealing for consumption in future. The colour of bael pulp powder is golden poppy in direct sun drying; light brownish in hot water, orange in hot sand and orange/burnt orange and rust in oven. Before this, fruits are cracked and treated with (i) hot water at 70°C for 1 hour, (ii) hot sand for 2 hours, (iii) oven for 2 hours at 70°C, after that rind of bael fruit is broken and removed the bael pulp and dried in direct sun light. The flow chart- 6 is given in for the preparation of bael powder.

3.7 Bael Jam

Jam is a concentrated fruit product processing a fairly heavy body, rich in natural fruit flavour. Pectin in fruit gives it a good set and high concentration of sugar facilitates its preservation. It is prepared by boiling the fruit pulp and juice with sufficient quantity of sugar to a reasonably thick



Fig. 9: Bael Jam

consistency to hold the fruit tissues in position. A fruit jam should contain minimum 45% of fruit portion and minimum 68% of total soluble solids (Fig. 9). The methods of making bael jam are given in flow chart-7.

3.8 Bael Slab

It is also known as leather or paper. Ripe fruits are used in its preparation. Wash ripe fruits and collect fruit pulp by breaking fruits and removing its hard shell. Add 200-300ml of water for each one kg of fruit pulp, mix well and heat it up to 80°C. Collect fruit pulp free of seeds and fibers by straining heated mass through stainless steel sieve. Sugar, citric acid and potassium metabisulphite (KMS) to this pulp is added so that treated pulp contains 35% total soluble solids, 0.5% total acidity and 0.07% KMS. Then, boil the treated pulp and spread on aluminium trays smeared with butter followed by drying at 55-60°C for 15-16 hours to a moisture content of 14.5%. Cut slabs of dried pulp in aluminium trays, wrap in butter paper and pack in polyethylene bags. Addition of up to 10 % sugar to the extracted pulp is found to be ideal before drying the pulp to moisture content of 14.5 % (Fig. 10). The method of preparation of bael slab is given in flow chart -8.



Fig. 10: Bael slab

3.9 Bael Toffee

Fruit toffees generally are more nutritious than ordinary toffees, and bael fruit pulp will provide even better toffees because of its nutritional and medicinal properties. Bael fruit toffees are successfully prepared by mixing 40 parts of cane sugar, 4.5 parts of glucose, 10 parts of skim milk powder and 6 parts of hydrogenated fat to 100 parts of extracted pulp. The final moisture content of the toffee is kept at 8.5%. The procedure of making bael toffee is given in flow chart-9.

3.10 Bael Wine

Generally, wine is prepared from the fresh ripened fruits. Several tropical and subtropical fruits like mango, litchi, kiwi, banana and cashew apple have been found suitable for wine making mainly because of their high sugar and water content, appropriate taste, flavour and seasonal availability. Bael fruits are seasonally available in tropical countries like India in huge quantities during the summer (May- June). There is an ample scope to bio process the fruits (rich in bioactive compounds and nutritional attributes) into value-added products such as wine to preserve the fruit nutrients, aroma and taste to be available round the year. Further studies are proposed to evaluate wine prepared from various clones of bael fruits collected from different agro- climatic zones. The composition of wine of bael fruit is presented in Table 3. The procedure of making bael wine is given in flowchart-10.



Table 3. Composition of bael wine (100 ml) (Source:Panda *et al.*, 2014)

Parameters	Baelwine
TSS (^o Brix)	2.90±0.0
Total sugar(g/100ml)	2.03±0.12
Titrateable acidity(g tartaric acid/ 100 ml)	0.15±0.07
pH	4.10±0.02
Phenol (g/100ml)	0.93±0.03
β-carotene (mg/100 ml)	33.00±0.01
Ascorbicacid(mg/100ml)	80.00 ±0.01
Lactic acid(mg/100ml)	0.64±0.06
DPPH (%)	48.00±2.20
Ethanol(%)	7.87±0.31

±Standard error

3.11 Bael Panjiri

This product is highly nutritive, restorative and is prescribed for stomach ailments. It is prepared by roasting 1 kg bael powder in 1 kg desi ghee and adding 1.5 kg sugar powder to it and mixing well. Roast wheat flour is added in small amount as per taste in desi ghee. All the ingredients are then mixed.

3.12 Flavoured bael products

Sometimes, the flavour of bael pulp is not acceptable to some people. In this case, by blending the pulp with spices (cardamom and ginger) may make it palatable and acceptable. In addition to this, blending of pulp may enhance the nutritional qualities compared to the pure product. Nutritive value of candy prepared by incorporation of different flavours showed that the energy, protein, fat, carbohydrate, fiber, calcium, iron, and phosphorus increases by incorporation of ginger and cardamom whereas the nutritive value did not change with the incorporation of rose. The nutritive value of the blended products with the incorporation of 2% each of ginger, cardamom and rose extract, are shown in table 4-6.

Table 4. Nutritive value of candy with flavours (100g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Ginger	309	0.67	0.10	76.41	0.98	36.23	0.27	17.62
Cardamom	310	0.73	0.11	76.60	1.09	36.95	0.28	18.28
Rose extract	308	0.62	0.10	76.33	0.96	36.09	0.25	17.22

Table 5. Nutritive value of jam with flavours (100g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Ginger	265	0.96	0.15	65.03	1.46	48.22	0.41	25.84
Cardamom	267	1.04	0.17	65.32	1.63	49.31	0.42	26.83
Rose extract	265	0.94	0.15	64.91	1.44	48.02	0.37	25.25

Table 6. Nutritive value of chutney with flavours (100g)

	Energy (Kcal)	Protein (g)	Fat (g)	Carbohydrate (g)	Fiber (g)	Calcium (mg)	Iron (mg)	Phosphorus (mg)
Ginger	231	1.28	5.39	44.29	1.79	53.59	0.66	36.82
Cardamom	233	1.38	5.42	44.61	1.98	54.74	0.67	37.86
Rose extract	230	1.27	5.39	44.17	1.77	53.38	0.63	36.20

3.13 Non-edible Uses

Corrosion in pickling cans or sheets made of mild steel can be inhibited by a protective film prepared from the aqueous extract of the plant in 1N hydrochloric acid and has an efficiency of 96-98%. Aegelin, an alkaloid compound in bael has been associated with this protective property. Muco adhesive material can be extracted from bael fruits which when used in formulating oral muco adhesive coated terbutaline sulfate tablets. In the presence of other heavy metal ions, the bael plant leaves act as effective bio-adsorbents of lead. This property can be used to control pollution of lead-laden effluents from the industries. Toxic Cr (VI) metal can be removed from aqueous phase by using non-usable fruit shell as an efficient low cost adsorbent. Along with other normal fatty acids, the seeds of bael fruit give oil which contains 12.5% of an unusual fatty acid ricinoleic acid. Bael seeds prove to be a good alternative feed stock for bio-diesel production when evaluated on various parameters relevant to bio-diesel like cetane number, lower heating value and higher heating-value.

3.14 Other uses of Bael

The unripe seed contains gum which may be used as adhesive for jewellery, lime plaster or cement can be mixed with, for waterproofing or plastering walls. For textile prints, dyeing of silk fabrics the yellow dye obtained from tannin can be used. Mermelle oil has been used by the Dutch of Ceylon. Bael could be used in preventing scum formation and preparing carts. Tool and knife handle, small-scale turnery, pestles and combs are prepared from it. Insecticidal activity is found against brown plant hopper. Methanolic bael extract shows anti-parasitic activity against *Haemaphysalis bispinosa*. Activated carbon from the bael fruit shell may act as an adsorbent to remove Chromium (VI) toxic metal from the aqueous system. Lead (II) can be removed when present with other metals from exhausted batteries by the use of bael.

3.15 Utilization of processing waste of bael

The bael peel and pomace constitute 35-40% of the total fruit weight and these wastage could be utilized for cattle feed. Peel contains 27.34% crude fibre, 31.85% crude protein, 1.0%Ca and 0.14% phosphorus whereas pomace contains 9.98, 10.5, 1.2 and 0.1 % of crude fibre, crude protein, calcium, and phosphorus respectively. Palatability of these wastes is adjusted by feeding to the cows after mixing with cattle feed in a ration 1:3. After mixing with the cattle feed, wastes are readily acceptable to the cows, which confirmed that it can be used as animal feed. In vitro digestibility of various constituents is also analysed and it is observed that 40.1% of total peel and 69.6% of the pomace is digestible. Use of these wastes as animal feed not only reduce the feeding and processing cost but also prevent health hazards and environmental pollution.



4. Economic analysis

Let us take 100 no's of fresh mature bael fruit.

Gross weight = $100 \times 0.65 \text{ kg} = 65 \text{ kg}$ (taking average weight of 650 g/piece)

Pulp recovery (@60%) = $65 \times 0.06 = 39 \text{ kg}$

Fixed cost:

Depreciation cost (equipments and assets) = Rs. 250.00

Interest on fixed capital (land and building rent) = Rs. 600.00

Total fixed cost = Rs. 850.00

Variable cost:

Cost of raw materials ($100 \times \text{Rs.}12$) = Rs. 1200.00

Cost of preservative (citric acid) = Rs. 150.00

Cost of sugar = Rs. 950.00

Packing cost = Rs. 2400.00

Cost of labour = $325 \times 4 = \text{Rs.} 1300$ (@ Rs.325/day)

Cost of fuel = Rs. 400.00

Cost of electricity (20 units) = $20 \times 3 = \text{Rs.} 60.00$

Total variable cost = Rs. 6460.00

Grand total (fixed +variable) cost = Rs. 7310.00

Quantity of RTS (15% TSS) juice prepared = $39 \times 100 / 15 = 260 \text{ litre}$

Number of RTS juice bottle prepared = $(260 / 0.20) = 1300$ (bottle capacity 200 ml)

Selling price of juice = $1300 \times \text{Rs.} 15 / \text{bottle} = \text{Rs.} 19,500.00$

Profit (Rs) = $19500 - 8210 = \text{Rs.} 11290.00$

It takes two days for final preparation and packaging, then profit per day = $\text{Rs.} 11290 / 2 = \text{Rs.} 5645.00$

Monthly profit = $\text{Rs.} 5645 \times 15 \text{ days} = \text{Rs.} 84675.00$

B:C ratio = 2.66



5. Summary

Bael is a native fruit tree of India. It has a number of bioactive compounds. It is a reservoir of various nutrients as well as a number of bioactive compounds and has number of therapeutic, non-therapeutic as well as religious uses. The management and production of bael is mostly done by unorganized sector and not much emphasis is given for its commercial utilization. The fruits could be effectively utilised with the use of proper technology for the benefit of end users. After harvest, it can be stored for 10-15 days at normal temperature, whereas fruit harvested at ripe stage can be stored for a week. With the application of NAA and GA3 etc, its shelf life could be increased so that the fruits may be consumed during off seasons. After extraction of bael pulp, it can be used for the preparation of various products viz., preserve, candy, jam, RTS, nectar squash/leather/slab, powder etc. In addition to this, blended products with spices add more values in terms of nutritional qualities. This may pave the ways for its scientifically exploitation and dissemination to cater rural women and other stake holders. As its flavour is acceptable by almost all the sections of society as a refreshing summer drink which shows that it has a lot of potential for value addition and production of by-products. Phyto-constituents in bael can be used for the treatment of various disorders in human being such as diabetes, liver toxicity, fungal infection, microbial infection, inflammation, pyrexia etc.

Women are the backbone of a family as well as a country. Still, their contributions are not neglected by men dominated society. In rural India where agriculture is the major source of income and livelihood, economic empowerment through value addition and product diversification is the need of hour with respect to loss reduction and better price realization. Being underutilized fruit and seasonality of production, value addition in bael is still in infancy stage. But in summer, there is huge market demand of bael based products, particularly RTS bael. Besides its home scale use, women SHGs could take this opportunity for the development of value added products and selling it to local markets for better income generating activities. The economic analysis shows B:C ratio of 2.66 which indicates a lucrative business by rural women in utilising bael fruit. Publicity, awareness campaigns and trainings are important and innovative approaches of popularization which will help in capturing the market share. Policy makers are to be sensitized on health and nutritional benefits of processed bael products on target populations such as school children-midday meal scheme and poor social groups PDS system and health-conscious consumers.



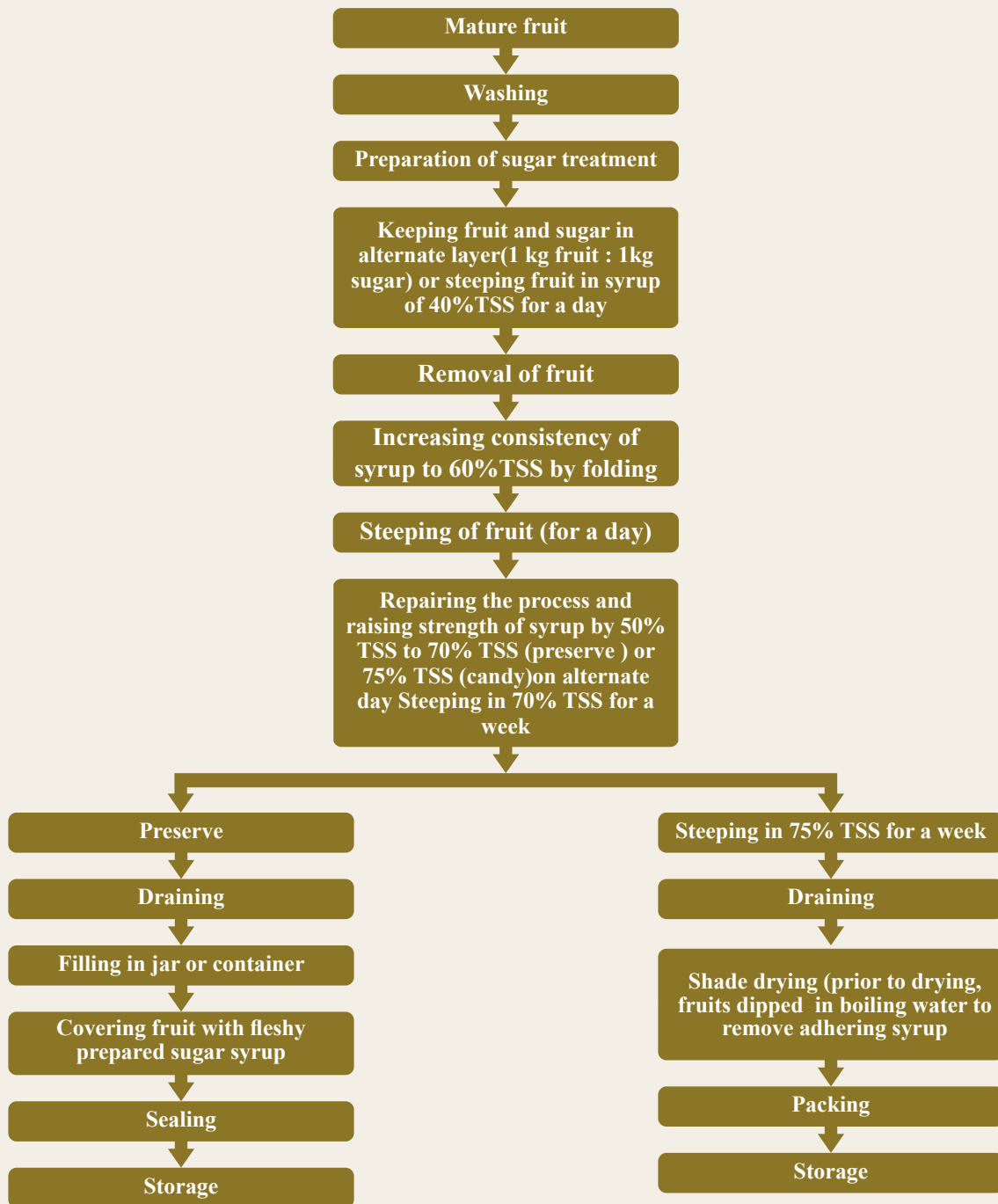
References:

1. Panda S.K., Sahu, U.C., Behera, S.K. and Ray, R.C. 2014. Bio-processing of bael [*Aegle marmelos* L.] fruits into wine with antioxidants. *Science Direct*. pp: 34-41.
2. Sarkar, T., Salauddin, M. And Chakraborty, R. 2020. In-depth pharmacological and nutritional properties of bael (*Aegle marmelos*): A critical review. *Journal of Agriculture and Food Research*. pp: 1-22.
3. Singh, R., Mishra, K.K. and Jaiswal H R. 2000. Studies on physic-chemical characters of fruits of bael genotypes. *Indian Journal of Horticulture*, 57 (4), 314-317.
4. Srivastava K.K. and Singh H.K. 2004. Physico-chemical quality of bael (*Aegle marmelos* correa) cultivars. *Agricultural Science Digest*. Vol. 24 (I), pp: 65-66.
5. Saini R. S., Singh, S. and Deswal, R. P. S. 2004. Effect of micro-nutrients plant growth regulators and soil amendments on fruit drop, cracking, yield and quality of bael (*Aegle marmelos* Correa) under rain fed conditions. *Indian Journal of Horticulture*. 61 (II) pp: 175-176.
6. Sharma, J., Painuli, R.M., Gaur, R.D. 2010. Plants used by the rural communities of district Shahjahanpur, Uttar Pradesh. *Indian J. Traditional Knowledge*, 9, pp. 798-803.



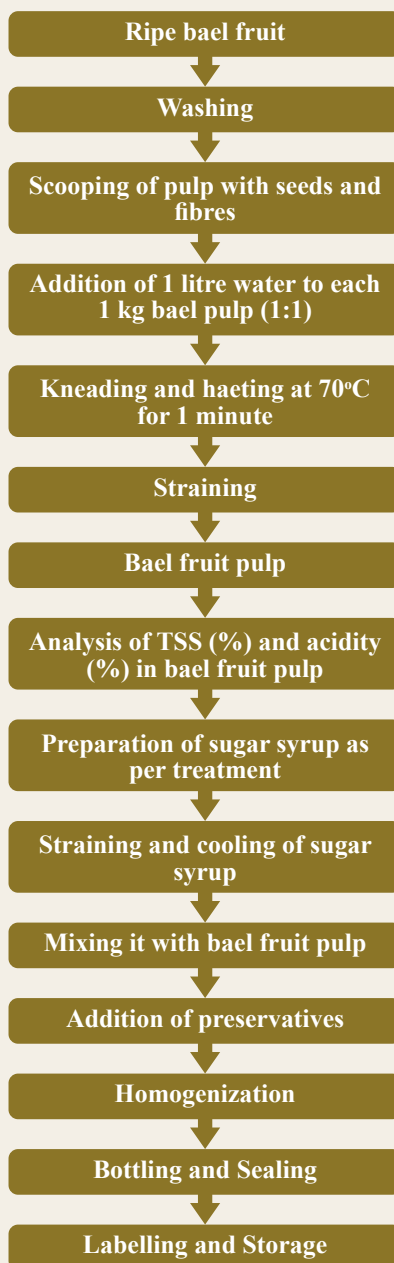
Flow chart-1(For preserve and candy)

Annexure



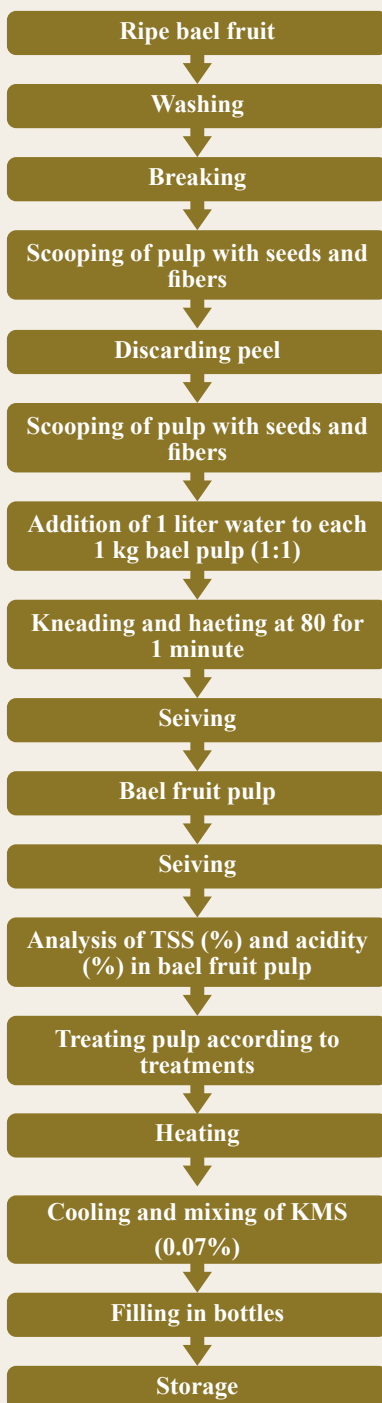
Flow chart-2 (Bael fruit squash)

Annexure (Contd.)



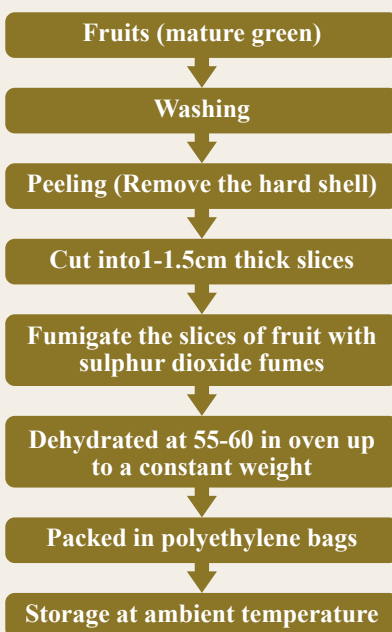
Flowchart-3 (Bael fruit pulp)

Annexure (Contd.)



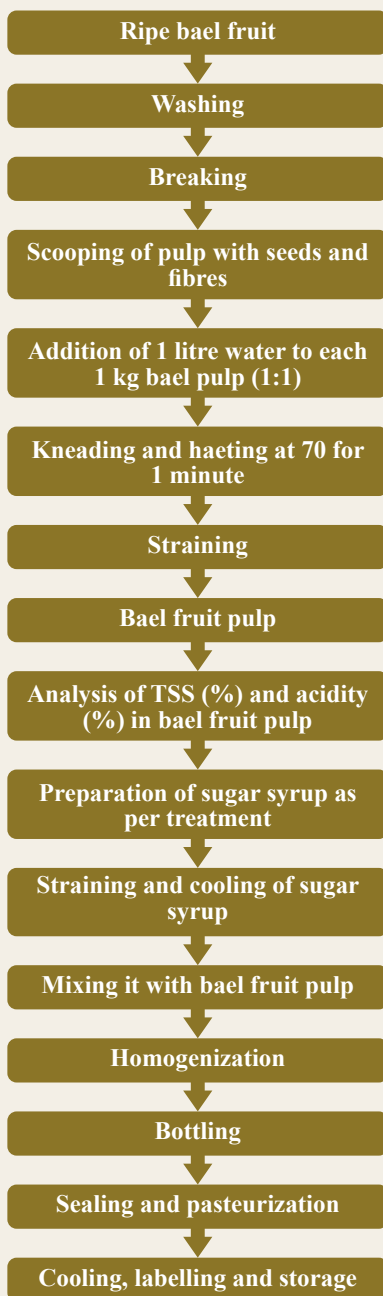
Flow chart-4 (dehydrated Bael)

Annexure (Contd.)



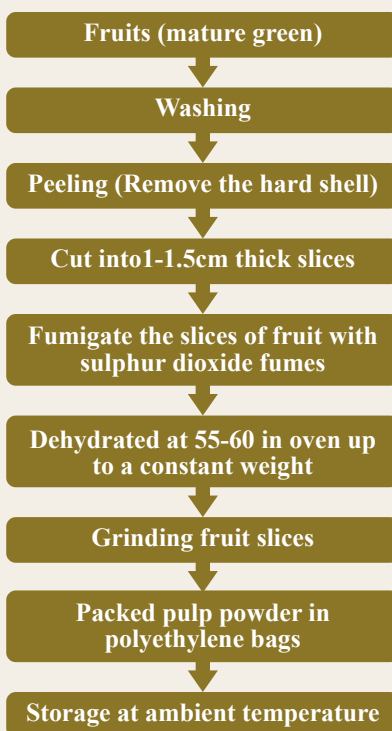
Flow chart-5 (Bael ready-to-serve (RTS Bael))

Annexure (Contd.)



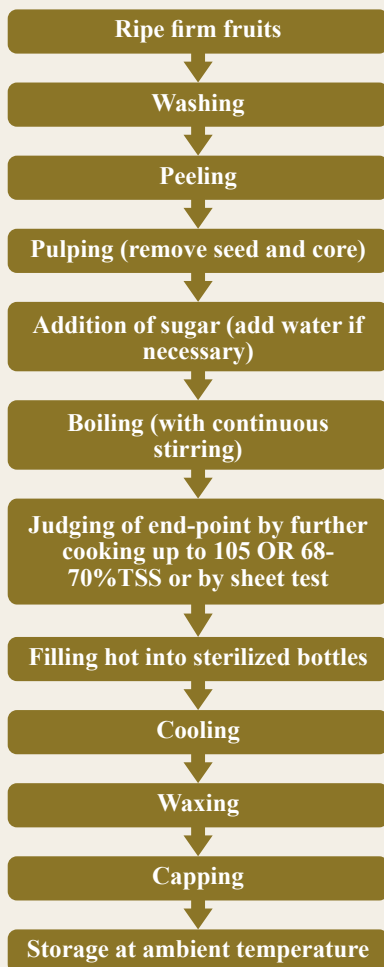
Flow chart-6 (Bael powder)

Annexure (Contd.)



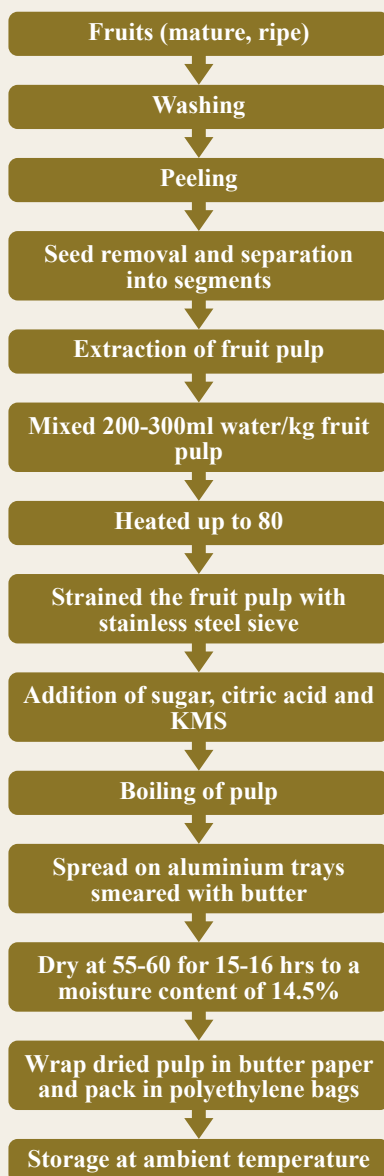
Flowchart -7 (Bael Jam)

Annexure (Contd.)



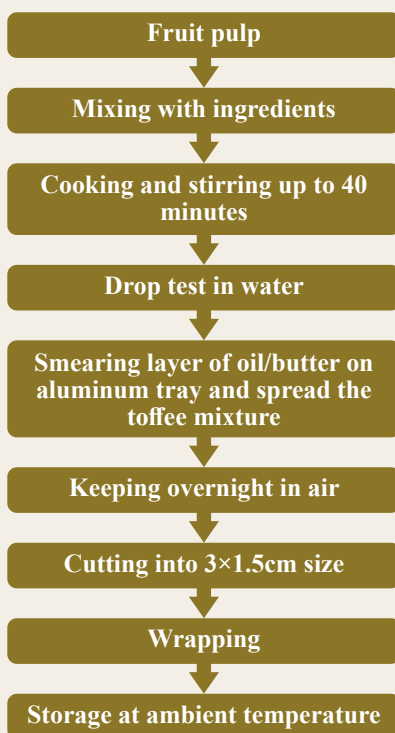
Flow chart-8 (Bael Slab)

Annexure (Contd.)



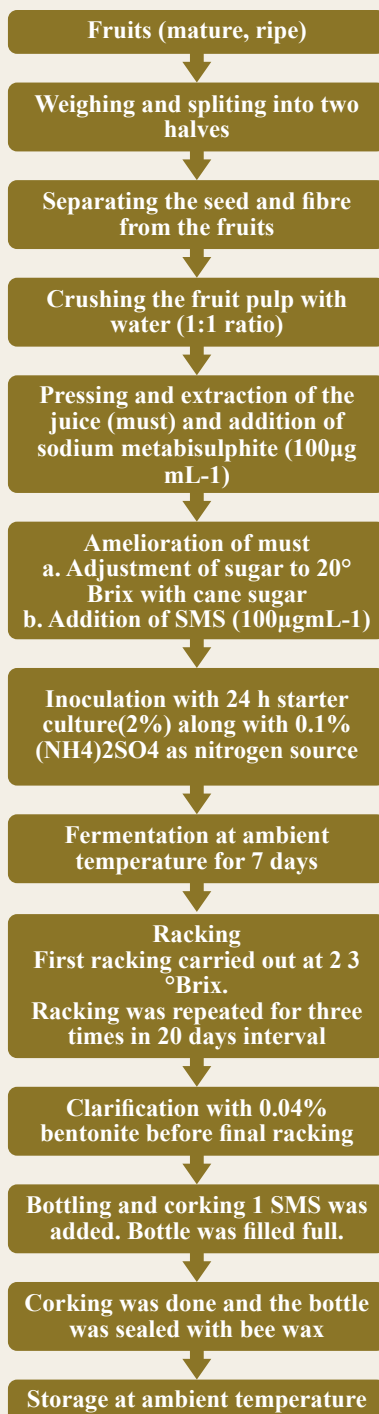
Flow chart-9 (Bael toffee)

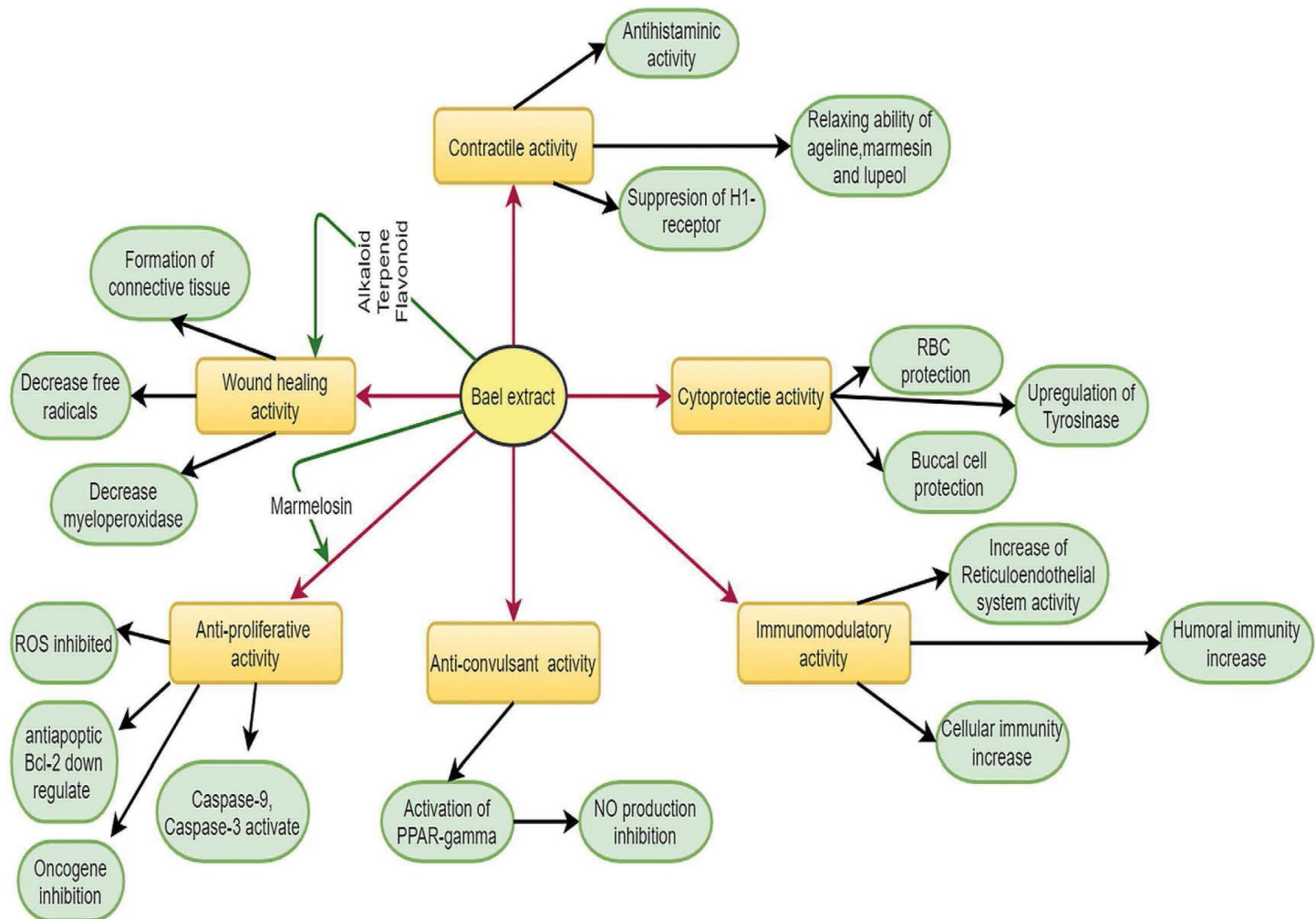
Annexure (Contd.)



Flow chart-10 (Bael Wine)

Annexure (Contd.)







भा.कृ.अनु.प. -केन्द्रीय कृषिरत महिला संस्थान
(भारतीय कृषि अनुसंधान परिषद)
भुवनेश्वर - 751 003, ओडिशा, भारत

ICAR- CENTRAL INSTITUTE FOR WOMEN IN AGRICULTURE
(Indian Council of Agricultural Research)
Bhubaneswar - 751 003, Odisha, India