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Post Harvest Management and value addition in Bael (*Aegle marmelos* Corr.)

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Abstract

The bael fruit is known for its medicinal properties and is one of the most nutritious fruits. It contains 61.5 g of water, 1.8 g of protein, 1.7 g of minerals, 31.8 g of carbohydrates and 1.19 mg of riboflavin/100 g edible portion. Its food value is 88 calories/100gm. Thus, it is richer than most of the reputed fruits like apple, guava and mango which have a calorific value of only 64, 59 and 36 respectively. It may be noted that no other fruits has such a high content of riboflavin. They are useful in curing dyspepsia, dysentery, diarrhea, vitiated condition of vata, vomiting, cardiopalmus, stomachalgia, intermittent fever, seminal weakness, swelling, uropathy and gastric irritability in infants. The bark decoction for malaria and leaves are useful in ophthalmia, deafness, and diabetes and asthmatic complaints. The flowers allay thirst vomiting. The unripe fruits are acrid, astringent, bitter, digestive, sour, stomachia and are useful in dysentery-diarrhea and stomachalgia. Bael fruit can be stored for 10-15 days at normal temperature, whereas fruit harvested at ripe stage can be stored for a week. After extraction of bael pulp used for the preparation of various fruit products viz., preserve, candy, jam, RTS, nectar squash/leather/slab, powder etc., which can be commercially exploited.

Keywords: Bael, post harvest management, value addition, quality

Introduction

Bael (*Aegle marmelos* Corr.) is an indigenous fruit of India belongs to family Rutaceae and it is commonly known as Bengal quince (John and Stevenson, 1979), Indian quince, Golden apple, Holy fruit, Bel, Belwa, Sripthal, Stone apple and Maredo in India. Bael fruit is a sub-tropical, deciduous tree and fruit is globuse 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 (Kaushik et al. 2002). Bael fruit is truly popular for its ability to combat constipation. Its medicinal properties have been described in the ancient medical treatise in Sanskrit in *CharakaSamhita* (Aiyer, 1956). 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 for a long time. The unripe bael fruits are used for pharmaceutical use (Hema and Lalitha Kumari, 1999; Pattanayak and Mohapatra, 2008), therapeutic use and preparation of jams, marmalade and syrups (ITDG, 2000). The fruit's medicinal value is very high when it just begins to ripen. The fruit is aromatic, cooling and laxative. It is useful in preventing or curing scurvy (Kartikar and Basu, 1935) and it also strengthens the stomach and promotes its action. Bael is considered to be one of the richest source of riboflavin (Mukharjee and Ahmad, 1957) and provides lots of minerals and vitamins to diet (Barthakur and Arnolds, 1989). The pulp also contains a balsam-like substance, and 2 furocoumarins-psoralen

and marmelosin ($C_{13}H_{12}O_3$), highest in the pulp of the large, cultivated forms. 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 (Singh, 2007).

Importance

Key to giving a fillip to India's food production would be minimization of all the wastages in the food distribution. Wild varieties of plants, yielding edible fruits growing throughout the Himalayas, contributed directly to cultural heritage of India. Even today, these fruits are eaten in plenty by local people, as they are commonly available in abundance in their habitats. Bael fruit have many advantages in terms of cultivation, hardy in nature and production of good crop even under adverse conditions. Underutilized fruit crops play crucial role in successful running of processing industry round the year in the region. A large proportion of rural population depends on locally available fruits to meet their dietary requirements. These fruit crops have their own history of consumption, local people are well aware their nutritional and medicinal properties (Patel *et al.*, 2008).

NUTRITIVE VALUE/BENEFITS

Bael fruit is highly nutritive with a great medicinal use and the richest source of riboflavin. Gehlot and Dhawan (2005) reported about all parts of the trees viz. root, bark, leaves, flowers or fruits are used for curing one or other human ailment. The roots are sweet, astringent, bitter and febrifuge. They are useful in curing dyspepsia, dysentery, diarrhea, vitiated condition of vata, vomiting, cardiopalmus, stomachalgia, intermittent fever, seminal weakness, swelling, uropathy and gastric irritability in infants. The bark decoction for malaria and leaves are useful in ophthalmia, deafness, and diabetes and asthmatic complaints. The flowers allay thirst vomiting. The unripe fruits are acrid, astringent, bitter, digestive, sour, stomachia and are useful in dysentery-diarrhea and stomachalgia. The ripe fruits are sweet, aromatic, cooling, febrifuge, 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. There is as much as 9% tannin in the pulp of wild fruits, less in the cultivated types and rind contains up to 20%.

PROPAGATION AND AGRONOMIC PRACTICE

Bael is successfully propagated through budding (patch, chip and T-budding). Patch budding is found very successful in the months of June-July, whereas, it can be grafted on *Aeglefraeglegabonensis* and *Aeglopsischevalieri* (Mitra, S.K. 1999). Grafted or budded plants are planted at a distance of 8 x 8m during July-August or February-March. Pits of one cubic meter size are dug two months prior to planting. In each pit, 3-4 basketfuls of well rotten FYM and 1Kg neem cake or 500g of bone meal is mixed with top 50% soil and filled. In sodic soil as per gypsum requirement 5-8kg gypsum along with 20kg sand is also incorporated. For good growth, yield and quality production of bael trees, manure and fertilizer application should be done judiciously. A dose of 5kg FYM, 50g N, 25g P and 50g K/plant should be applied to one year old plant. This dose should be increased every year in the same proportion up to the age of 10 years. Thereafter, a constant dose of 500g N, 250g P and 500g K along with 500kg FYM should be applied. In bael orchards, where fruit cracking is a problem, 300g borax/tree should also be applied along with the manure and fertilizers. Full dose of manure and fertilizers should be applied in June-July (Peter, K.V., 2008).

HARVESTING AND YIELD

Fruits are ready for harvest in April-May when the fruits shell changes its colour from deep green to yellowish green. The fruit should be picked individually, so that it does not fall on the ground to avoid cracking of the shell which may lead to spoilage during storage. The stem end of fruit is prone to infection. Therefore the fruits should be harvested along with a portion of stalk (approximate 2cm). The stalk automatically separated from the fruit when the fruit is ripe, thus it is an indication of ripening. Bearing in budded/grafted plants starts 3-4 years after planting, whereas in seedling trees 7-8 years. A 12-15 years old bael tree produces 300-500 fruits and the individual fruit was found to vary between 500g to 3000g. Yield varies greatly in bael varieties.

PHYSICAL CHARACTERISTICS

The bael fruits are hard-shelled berry usually globose (6-12cm diameter) with a nearly smooth pericarp. Pericarp of bael fruit is 3mm thick, hard and filled with soft and yellow fragrant pulp. The raw fruit, due to its high acidic nature and astringent taste, is unacceptable to consumers. Seeds are many, compressed and arranged in closely packed tiers in the cell surrounded by very tenacious, slimy, transparent mucilage, which becomes hard when, dried. The testa is white with wooly hairs and the embryo has large cotyledons (Hume, 1957; Ruther et al., 1967; Singh and Roy, 1984). Some variety like NB-9 are good in taste (35-40 °Brix) and average fruit yield is 70-80kg and rind of fruit is thin, flesh contains less fibre and seed, whereas, CISH-B-1 and CISH-B-2 are good in taste (35-41 °Brix), thin rind (0.1-0.12cm) and average yield is about 40-60kg (Peter, K.V. 2008).

CHEMICAL COMPOSITION

The chemical composition of bael fruits is influenced by environmental factors. The chemical composition of fresh fruit in respect of water, carbohydrate, protein, fat, minerals, carotene, thiamine, riboflavin, niacin and vitamin C has been reported by lot of researchers (Rakesh *et al.*, 2005) and shown in Table 1. The fruits are rich in carbohydrate, protein and riboflavin. Jauhari *et al.* (1969) reported that the bael fruit, T.S.S. and acidity ranged from 1283 to 2818g, 28 to 36% and 0.256 to 0.368%, respectively, and according to Jauhari and Singh, 1971, bael fruit contains 28-39 per cent total soluble solids (TSS), 19-21 per cent carbohydrates, 11-17 per cent sugar, 1 per cent protein, 0.2 per cent fat, 7-21 mg/100gm vitamin C. In addition, it is rich in vitamin A (186 IU/100gm pulp); volatile oils and marmlosines. Its food value is 88 calories/100gm. Thus, it is richer than most of the reputed fruits like apple, guava and mango which have a calorific value of only 64, 59 and 36 respectively.

STORAGE

The storage life of the fruit depends upon the stage of harvesting. Bael fruit can be stored for 10-15 days at normal temperature, whereas fruit harvested at ripe stage can be stored for a week. The storage life of bael fruit could be increased from 2 weeks at 30 °C to 12 weeks at 9 °C and 85-90% relative humidity (Roy and Singh, 1979). The ripe bael fruit could be made available 2-3months prior to schedule with the treatment ethrel (1000-1500ppm) and storing the fruits at 30 °C after harvesting in January. It took 18-24days for the fruit to be artificially ripened. The composition of fruits, ripened artificially or naturally, did not vary much, with slightly less sugar content reported in artificially ripened fruits (Roy and Singh, 1981). Bhadra and Sen (1998) reported that fruits wrapped with blue cellophane paper, butter paper, perforated polyethylene bagging + KMnO₄ and perforated polyethylene bagging, which showed maximum extension of shelf life of 24 days over other treatments. Among the chemicals by which fruits were treated, NAA 100 ppm, GA₃ 50 ppm, stannous chloride 250 ppm and cobalt nitrate 250 ppm were effective in extension of storage life and marketability of fruits. Singh (1998) mention that NAA and calcium nitrate were effective in minimizing the loss in weight, reduced the rate

of respiration, spoilage percentage and finally maintained the edible quality and marketability of fruits during storage of guava.

BAEL PRODUCTS AND USES

A large number of bael processed products (Preserve, candy, panjiri, toffee, jam etc.) are prepared and some scientist and researcher are already worked on their processed products. Rakesh et al., 2005 standardized the recipe of bael processed products are given in Table-2.

PRESERVE AND CANDY

Preserve and candy are prepared from mature (tender green fruit), hole or large pieces of fruits in which sugar is impregnated till its becomes tender and transparent minimum fruit portion and minimum total soluble solids in preserves should be 55 and 70%, respectively (Lal et al, 1960). 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 flavor, colour and texture of the product to a great extent and prevents its microbial spoilage (Bongirwar, 1997).

“A fruit of its pieces impregnated with sugar or glucose syrup, sub piquantly drained free of syrup 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 are given in Flow-chart-1.

Bael Fruit Squash

An ideal composition of bael fruit squash was found to be 50 per cent extracted pulp, 50 °Brix and 1 per cent acidity. The squash was chemically preserve by addition of 300 ppm SO₂ (Roy and Singh, 1979). Fruit beverages commercially contains at least 25 per cent fruit pulp or juice and 40-50 per cent TSS, besides 1 per cent acid (Srivastav and Kumar, 1993). The squash from bael fruit pulp was prepared by adjusting the TSS and by adding the preservatives like sodium metabisulphite @ 350 ppm SO₂ (Bhat and Kaul, 2006), and sodium benzoate @ 1g/litre (Verma and Gehlot, 2006). The squash was then filled in sterilized bottles, crowned and pasteurized at 80 °C for 30 minute followed by cooling and wax sealing to insure air tightness (Kenghe, 2008). The methods of making bael fruit squash are given in Flow-chart-2.

Bael Fruit Pulp

The ripe fruit were washed with tap water and broken by striking against hard object. The fruit pulp along with its seeds and fibres was scooped with the help of stainless steel spoon. Amount of water equal to the weight of pulp was added. The mixture of pulp and water was then heated up to 80⁰c for 1 minute and cooled. Pulp free from seeds and fibres was then obtained by passing through 20 mesh stainless steel sieve. The extracted bael pulp was improved by adjusting the TSS by addition of sugar and acidity by the addition of citric acid (Flow-chart-3) (Chand and Gehlot, 2006).

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 of fruits with sulphur dioxide fumes for an hour in sulphur box and dehydrated at 55-60⁰c in oven up to a constant weight. Pack dried slices in polyethylene bags or glass jar for future use (Flow-chart-4).

Bael Ready-to-serve (Bael RTS)

For preparing bael ready-to-serve (RTS) drink TSS (%) and acidity (%) in the extracted bael fruit pulp were analyzed. On the basis of analysis, requisite amounts of sugar and citric acid dissolved in required amount of water were added to measure quantity of bael pulp for adjustment of TSS (%) and acidity (%) in RTS drink as per treatments. The prepared RTS drink was thoroughly homogenized and filled in clean, sterilized 200 ml capacity glass bottles leaving 2-3 cm head space. The beverage filled bottles were sealed with sterilized crown corks, pasteurized in boiling water for half an hour, cooled in air and stored in cool and dry place (Verma and Gehlot, 2006 & 2007). The methods of bael RTS are given in flow-chart 5.

Bael Powder

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. According to Rani et al. (2009) the colour of bael pulp powder was found 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 were cracked and treated with A. hot water at 70 °C for 1 hour, B. hot sand for 2 hours, C. oven for 2 hours at 70 °C, after that, rind of bael fruit was broken and removed the bael pulp, and dried in direct sun light. Roy and Singh, 1979 reported that bael fruit powder was prepared by drying the pulp to a thin sheet to below 4 per cent moisture level and then grinding to powder (Flow-chart-6).

Jam

Jam is a concentrated fruit product processing a fairly heavy body, reach 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 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. The methods of making bael jam are given in Flow-chart 7.

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. At 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. Add sugar, citric acid and potassium meta-bisulphite (KMS) to this pulp so that treated pulp contains 35% total soluble solids, 0.5% total acidity and 0.07% KMS. Boil treated pulp and spread on aluminum trays smeared with butter. Dry at 55-60°C for 15-16 hrs to a moisture content of 14.5%. Cut slabs of dried pulp in aluminum trays, wrap in butter paper and pack in polyethylene bags (Flow-chart 8). Addition of up to 10 per cent sugar to the extracted pulp was found to be ideal before drying the pulp to a moisture content of 14.5 per cent (Roy and Singh, 1979).

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 were 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 was kept at 8.5 per cent (Roy and Singh, 1979). The procedure of making bael toffee are given in flow-chart-9.

Panjiri

Bael panjiri is highly nutritive, restorative and is prescribed for stomach ailments.

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Table 1: Chemical composition of fresh bael fruit (Food Value/100 g edible portions)

Characters	Composition
Water	61.5g
Carbohydrate	31.8g
Protein	1.8g
Fat	0.39g
Minerals	1.7g
Carotene	55mg
Thiamine	0.13mg
Riboflavin	1.19mg
Niacin	1.1mg
Vitamin C	7-21mg

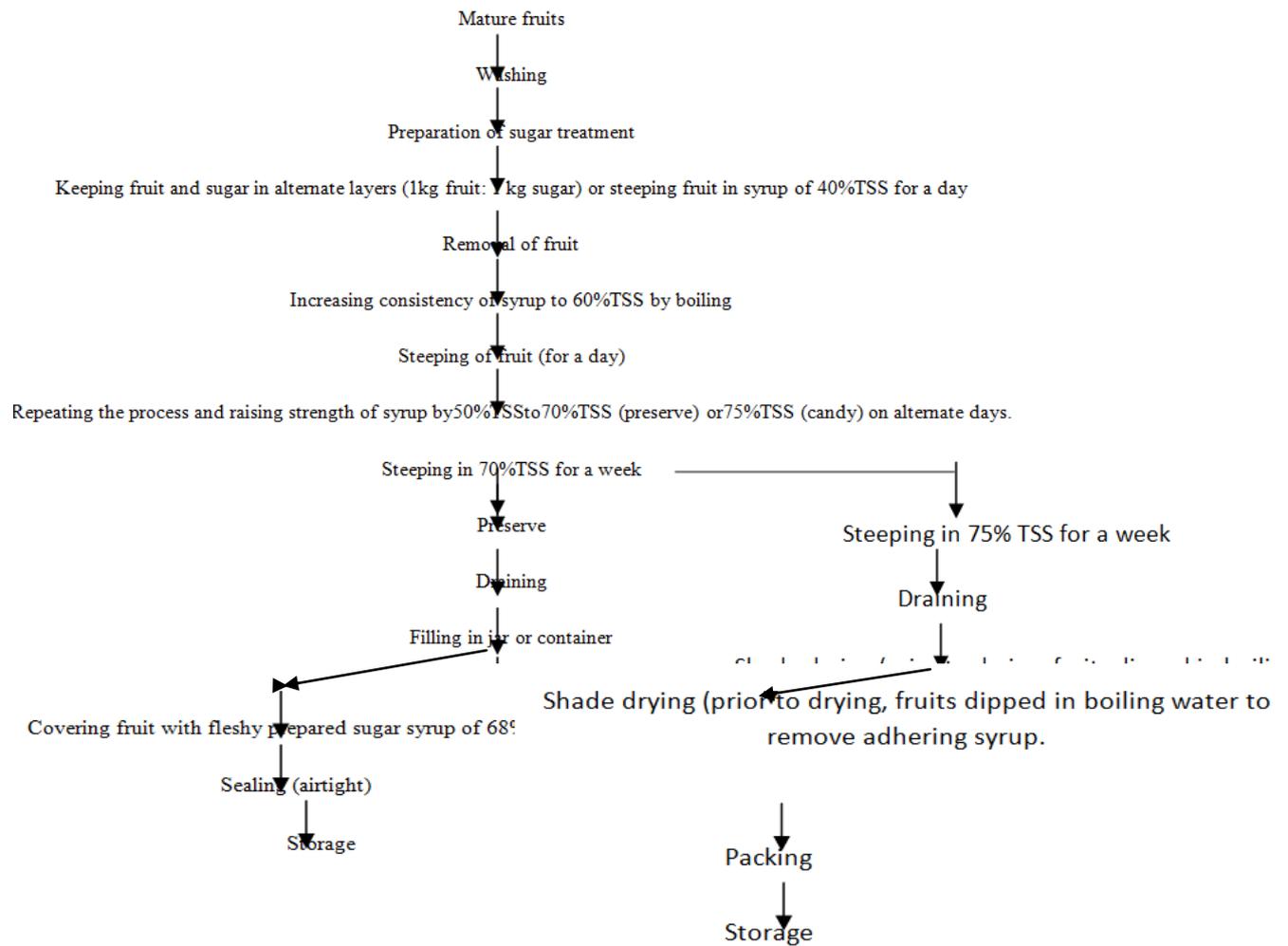
(Source: Rakesh *et al.*, 2005)

Table-2 Bael products and their recipe

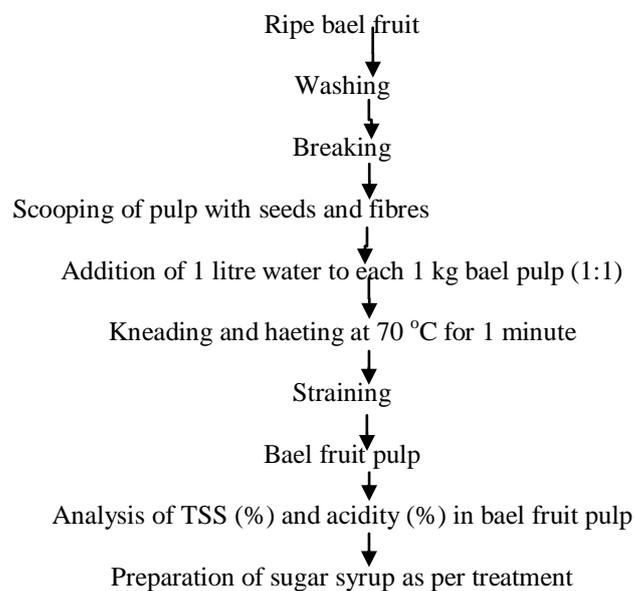
Products		Preserve	Candy	Panjiri	Toffee	Jam
Recipe	Fruit pulp(kg)	1	1	1	1	1
	Sugar (kg.)	1.25	1.25	1.5	0.5	0.75
	Citric acid (gm)	2-3	2-3	-	-	3-4
	Water (ltr.)	1	1	-	-	-
	Desi-ghee (kg)	-	-	1	-	-
	Roasted wheat flour	-	-	Q.S.	-	-
	Dry fruits	-	-	Q.S.	-	-
	Glucose	-	-	-	100	-
	Skimmed milk powder (gm)	-	-	-	150	-
	Butter (gm)	-	-	-	100	-
Remark		-	-	Prescribed for Stomach ailments	-	Minimum 55% of fruit portion and minimum 68% of TSS

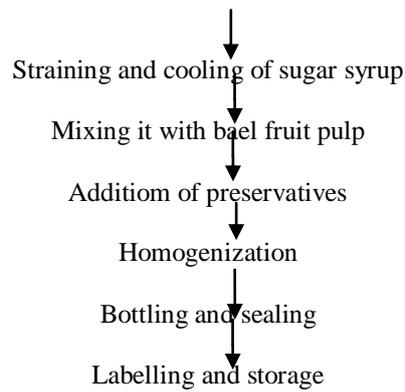
Q.S.-Quantity sufficient (Source: Rakeshet *al.* 2005)

Flow-chart-1: Technological flow-chart for processing of Preserve and Candy

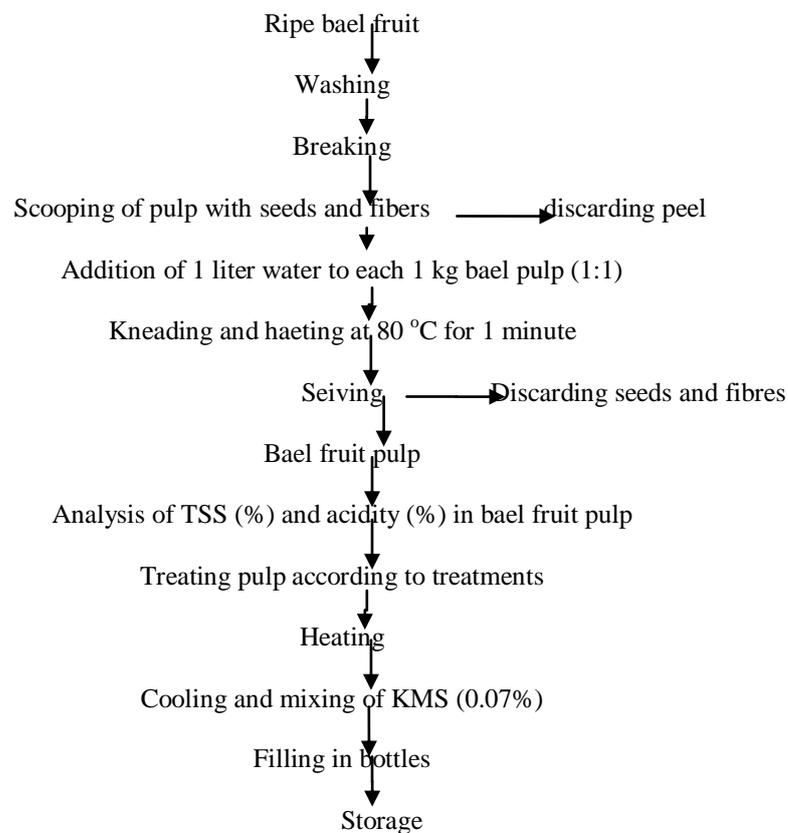


Flow-chart 2: Technological flow-chart of processing of Bael fruit squash

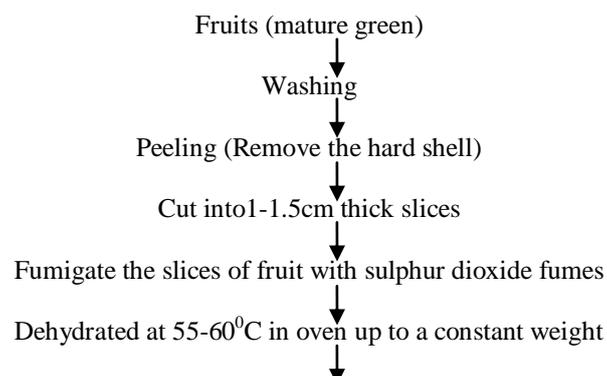




Flow-chart 3: Technological flow-chart of processing of Bael fruit pulp



Flow-chart 4: Technological flow-chart of processing of dehydrated fruit (Bael)



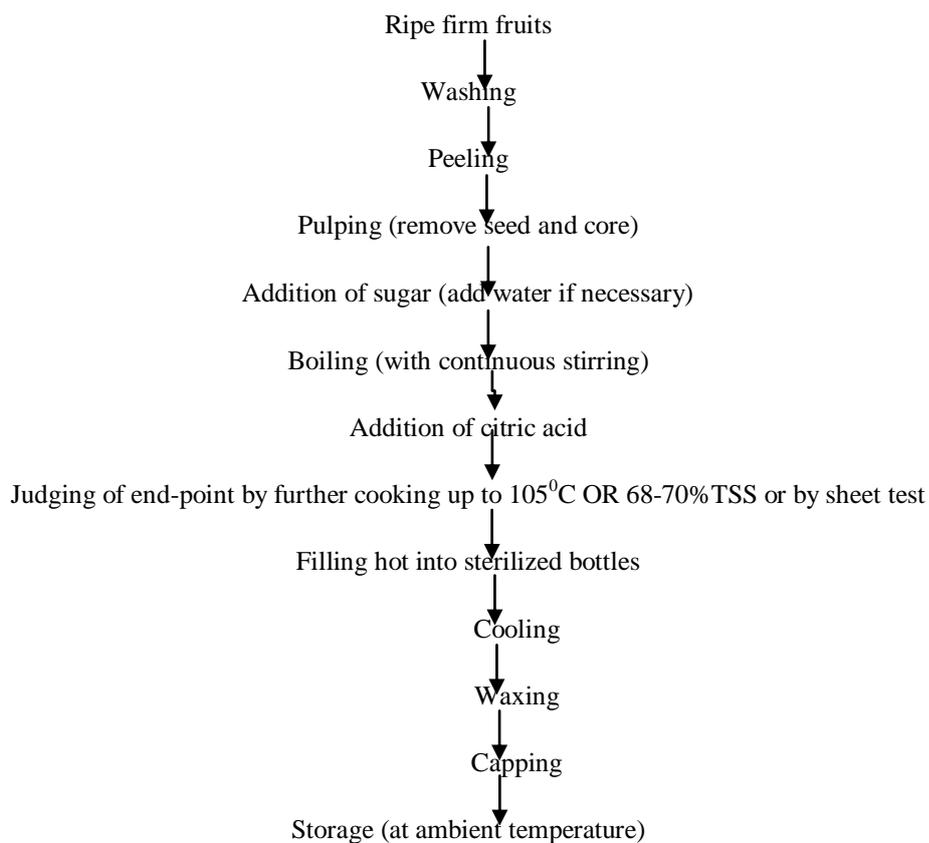
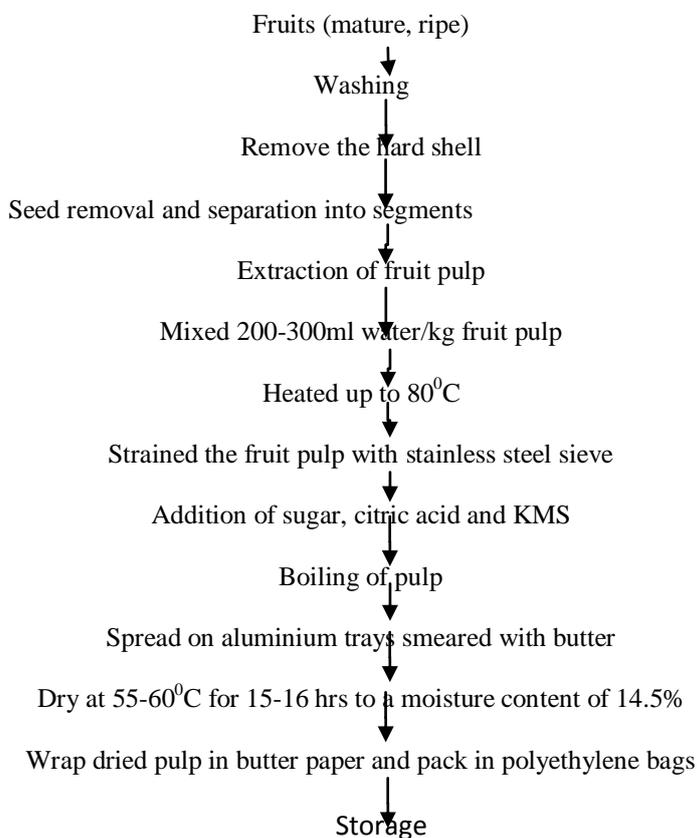
Packed in polyethylene bags
↓
Storage at ambient temperature

Flow-chart 5: Technological flow-chart of processing of Bael ready-to-serve

Ripe bael fruit
↓
Washing
↓
Breaking
↓
Scooping of pulp with seeds and fibres
↓
Addition of 1 litre water to each 1 kg bael pulp (1:1)
↓
Kneading and heating at 70 °C for 1 minute
↓
Straining
↓
Bael fruit pulp
↓
Analysis of TSS (%) and acidity (%) in bael fruit pulp
↓
Preparation of sugar syrup as per treatment
↓
Straining and cooling of sugar syrup
↓
Mixing it with bael fruit pulp
↓
Homogenization
↓
Bottling
↓
Sealing and pasteurization
↓
Cooling, labelling and storage

Flow-chart 6: Technological flow-chart of processing of fruit powder

Fruits (mature green)
↓
Washing
↓
Peeling / Remove the hard shell
↓
Cut into 1-1.5cm thick slices
↓
Fumigate the slices of fruit with sulphur dioxide fumes
↓
Dehydrated at 55-60°C in oven up to a constant weight
↓
Grinding fruit slices
↓
Packed pulp powder in polyethylene bags
↓
Storage

Flow-chart 7: Technological flow-chart for processing of jam**Flow-chart 8: Technological flow-chart of processing of fruit Slab**

Flow-chart 9: Technological flow-chart for preparation of fruit toffee

