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Review Article

A systematic review on processing and health benefits of wood apple

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Abstract

Wood apple (*Aegle marmelos*), also known as "bael" is a tropical fruit native to Southeast Asia. It holds significant importance in traditional medicine and has been recognized for its numerous health benefits. This review aims to explore the processing techniques of wood apple and highlight its potential health-promoting properties. The processing of wood apple involves several steps, including harvesting, ripening, and extraction of pulp. The extracted pulp can be consumed fresh or processed into various forms, such as juice, jams, syrups, or even used as an ingredient in culinary preparations. It is a good source of vitamins (especially vitamin C), minerals, dietary fiber, and antioxidants. The fruit is also known for its unique blend of bioactive compounds, including tannins, flavonoids, and alkaloids. These constituents contribute to its diverse health benefits. The fruit exhibits antimicrobial properties and helps combat bacterial and fungal infections. It also has hypoglycemic effects, potentially benefiting individuals with diabetes. The presence of bioactive compounds in wood apple suggests potential anticancer properties, although further research is needed in this area. Understanding the processing techniques and health-promoting properties of wood apple can provide valuable insights for the food industry and contribute to its integration into a healthy diet.

Keywords

wood apple, bioactive compounds, hypoglycemic, functional food

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Introduction

Wood Apple (*Feronia acidissima*) commonly known as Bael in various Indian languages is a sub-tropical edible fruit bearing tree found in Asia. It also grows in other parts of South East Asia, including Thailand, Bangladesh, Burma, Pakistan, Sri Lanka, and Myanmar. The primary growing states in India are Uttar Pradesh, West Bengal, Punjab, Bihar, Rajasthan, Orissa, Chhatishgarh, Madhya Pradesh, and Rajasthan. It may be found growing in subtropical, tropical, arid, and semi-arid regions of the nation. When ripe, the fruit has a globose, woody berry with a rind that is 3-5 inches in diameter and high in beta-carotene. The generic name Aegle comes from the fact that ripe bael fruit (golden in colour) resembles a golden apple (Panda et al. 2014). The fruit pulp contains 10 to 15 seeds and is quite mucilaginous. It also contains a lot of beta-carotene. Bael fruits include marmelosin, luvangetin, aurapten, psoralen, marmelide, and tannin, which are all bioactive substances (Maity et al. 2009). According to National Horticulture Board of India in 2015-2016 Bael production was 85.83 lakh tonnes, with highest production in the state of Odisha, it alone produced 48.56 lakh tonnes that holds 56.57% share (Anonymous 2019). The tree is very tough, requires very little care once established and can be propagated from seeds (Jayakumar and Geetha 2012). Due to its high tolerant property, it can be grown at varied range of temperature and rainfall. Almost all parts of the tree are used locally in Indian subcontinent as Ayurvedic medicines for various ailments. Roots, Bark, Leaves and tender fruits are used for the treatment of diarrhea, dysentery, etc. The fruit is spherical in shape with average length (longest dimensional axis), width (Intermediate Dimensional Axis) and thickness of 8.92, 8.22 and 7.95 cm respectively (Sonawane et al. 2020). The pulp of the fruit is soft yellow and protected by numerous strong fiber and outer covering shell. It is sweet and delicious and can be separated manually by scooping with spoon or ladle by hand or filtered out by adding some water to it. It can be used in many food items such as jam, jelly, ready to serve juice, chutney, etc. It contains high levels of phenolics, carotenoids, alkaloids, flavonoids, tannins, terpenoids, coumarins, and dietary fibre. Users enjoy the refreshing flavour of the bael juice and sharbat or syrup as well as the benefits they provide for nutrition and digestion (Singh et al. 2014). Recently, a ready-to-serve beverage made from bael pulp was created (Patanjali Ayurved Ltd., Haridwar, India), and Tropicana and other businesses have begun marketing as an ingredient in mixed fruit juice. This article deals with the studies related to the understanding the ways in which wood apples are processed and their health-enhancing qualities can help the food sector and promote their inclusion in a balanced diet.

Chemical composition of wood apple. Wood apple contains numerous nutritional properties that directly inflect health benefits. On analysing 100 grams of edible part of wood apple it was found to be containing 58.89 ± 1.21% moisture (on wet basis), 24.74 ± 0.19% carbohydrates, 9.30 ± 0.16% protein, 0.99 ± 0.01% fat, lumps of vitamins, minerals and traces of other health beneficial components (Lamani et al. 2022). The details of composition are shown in Table 1.

The study on wood apple pulp essential oil extract showed that the microbes such as Staphylococcus aureus and Bacillus cereus were very sensitive and hence can be assumed that the oil extract of the pulp of wood apple possesses natural anti-oxidant (Senthilkumar and Venkatesalu 2013). It also contains high amount of polyphenols i.e., bicyclo [2.2.1] heptane, 2-(1-buten-3-yl)-serverogenin acetate, 4H-pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-, L-(+)- -ascorbic acid 2,6-dihexadecanoate, cis-vaccenic acid, thiopene, 2-propyl- -phenol, 2,4-bis (1,1-dimethylethyl) and octanoic acid that can neutralize harmful free radicals (Karunanithi and Venkatachalam 2019; Ilaiyaraja et al. 2015). The pulp of wood apple analysed with High-Performance Liquid Chromatography (HPLC) with sulphuric acid as a mobile phase, Gas Chromatography (GC) and Gas Chromatography-Mass Spectrometry with Helium as a carrier gas, showed that it is predominant with fructose, glucose and organic acid (Lamani et al. 2022). The high amount of sugar, low in phenolics and mucilage makes the wood apple fruit delicious more palatable.

The pulp can be effectively dried in hot air oven at 70℃ (Goyary et al. 2021). It can be stored at room temperature (around 30℃) without any effect on bioactive nutrients (Sonawane and Arya 2015). The dried pulp can be milled and preserved for industrial

Table 1. Physico-chemical properties of wood apple(Compilated by Sonawane et al. 2020; Murakonda et al. 2022; Lamani et al. 2022 and Ilaiyaraja et al. 2014)

Sl. No.	Parameters	Quantity	Units
1.	Mass	232.75 ± 37.72	g
2.	Length (Longest Dimensional Axis)	7.79 ± 0.39	cm
3.	Width (Intermediate Dimensional Axis)	7.60 ± 0.39	cm
4.	Thickness (Short Dimensional Axis)	7.44 ± 0.37	cm
5.	Arithmetic Mean Diameter (D_a)	7.615 ± 0.37	cm
6.	Equivalent Mean Diameter (D_e)	7.613 ± 0.37	cm
7.	Geometric Mean Diameter (D_g)	7.613 ± 0.37	cm
8.	Sphericity (Ø)	0.977 ± 0.01	%
9.	Surface Area	182.45 ± 18.15	cm^2
10.	True Density (ρ_t)	0.99 ± 0.04	$g.cm^{-3}$
11.	Bulk Density (ρ_b)	0.42 ± 0.01	$g.cm^{-3}$
	Outer shell colour values		
	L^*	47.01 ± 2.61	-
	a^*	3.63 ± 0.44	-
12.	b^*	19.07 ± 1.44	-
	Chroma	19.42 ± 1.49	-
	Hue angle	79.24 ± 0.61	-
	Colour index	4.04 ± 0.22	-
	Pulp colour values		
	L^*	37.78 ± 0.58	-
	a^*	14.54 ± 0.56	-
13.	b^*	22.29 ± 0.92	-
	Chroma	26.62 ± 0.79	-
	Hue angle	56.86 ± 1.57	-
	Colour index	17.30 ± 1.13	-
	Fruit fraction		
	Shell	47.54 ± 3.99	%
14.	Pulp	41.38 ± 2.96	%
	Sheed	11.22 ± 1.20	%
15.	Pulp Gumminess	2.38 ± 0.07	N
16.	Pulp Chewiness	0.04 ± 0.02	J
17.	Moisture content (wet basis)	58.89 ± 1.21	%
18.	Total Soluble Solids	19.52 ± 0.17	°Brix
19.	Titratable Acidity	4.61 ± 0.13	%
20.	pH	3.61 ± 0.09	
21.	Total Carbohydrates	24.74 ± 0.19	%
22.	Total Protein	9.30 ± 0.16	%
23.	Crude Fat	0.99 ± 0.01	%
24.	Crude Fiber	3.32 ± 0.02	%
25.	Essential oil	41.35 ± 1.40	$\mu g.\ mL^{-1}$
26.	Total Phenolic Content	7.21 ± 1.40	$g\ GAE.g^{-1}$
27.	DPPH (2,2 diphenyl-1-picrylhydrazyl) Scavenging activity	81.60 ± 3.50	%
28.	ABTS (2,2-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid)) radical scavenging activity	85.20 ± 3.20	%

uses also (Vijayakumar et al. 2013). Mixing the powder with curcumin in the ratio of 1:4 makes a healthy tea drink containing high Beta-Carotene and vitamin B-complex (Minh and Oanh 2018). By adding 6% fruit powder and 20% table sugar low calorie and 5 to 6 d shelf-life extended fruit yogurt can be prepared (Panda et al. 2014). The juice prepared from wood apple exhibit therapeutic value and can reduce blood sugar level, creatinine level, blood pressure and increase haemoglobin (Anitha et al. 2015). Ready to serve beverage can be prepared and preserved for minimum of 50 d by adding permissible limit of KMS (50 ppm), citric acid, ascorbic acid and sodium benzoate with very low or no growth of microbes (Moazzem et al. 2019). Fermenting the juice of wood apple with *Saccharomyces cerevisiae* produces beta carotene rich wood apple wine which has been proven to be anti-diarrheic, anti-inflammatory and anti-bacterial (Panda et al. 2014). Burfi one of the favorite confectionery items of India is a partially dehydrated whole milk with various flavor blend. Herbal burfi with wood apple flavour blend can be prepared with 10% in the mixture of ingredients (Navale et al. 2014). About 20% addition enhances flavor as well as high overall sensorial acceptance (Gadekar et al. 2017). A frozen dessert Kulfi is a blend of skim milk powder and other milk components along with sugar flavor and colorants. About 15% addition of fresh wood apple pulp increases the nutritional property and colorants can be replaced (Singh et al. 2017). Kalak and one of the indigenous milk products of India can also be made successfully by replacing the milk component channa with wood apple pulp which is much cheaper and easily available (Kumar and Singh 2017). Jam and fruit bar prepared from whole pulp can be preserved and safely consumed for 90 d (Vidhya and Narain 2017). Preserve and Candy from the fresh ripe pulp can be prepared and commercialized as a therapeutic product (Singh et al. 2017). Pickle can also be successfully produced from the ripe fruit and stored for 90 d without organoleptic and Nutra-chemical changes (Rathore et al. 2021).

Even the hard protective layer shell of the fruit finds various uses in adsorption, reinforcement and production of carbon black production. The adsorbent prepared from the dried powdered shell of wood apple was found to be high in adsorption capacity of crystal violet and methylene blue (Jayaram and Jain 2010). Chemically activated with H_2SO_4 at 600℃ for 2 h can remove Cr (VI) from aqueous solution (Kailas and Khan 2017). It can also remove environmentally persistent and acutely toxic malachite green from aqueous solution (Sartape et al. 2017). The composite material prepared was found that it has higher flexural strength than regular epoxy (Srivastava and Mishra 2014). Carbon black derived from wood apple shell produced by pyrolysis of shell particles at 400℃ showed semi ductile type failure and minimum wear as compared to another raw particulate composite (Ojha et al. 2014a). The comparison of reinforcement polymer composite produced from bio-waste of wood apple and coconut showed that wood apple shell has flexural strength of 78.19 MPa which is much higher than that of coconut (Ojha et al. 2014b). The low-cost adsorbent produced from pyrolysis of bio-waste of wood apple can eliminate phenol chlorophenol compounds from effluent (Kumar et al. 2021). The study of various uses of wood apple was undertaken to highlight the versatility of the fruit in producing many products. In this review paper details of confectionery products prepared from the pulp of wood apple has been discussed.

Phytochemical and Antioxidant Properties of Wood Apple

The naturally occurring chemical compounds in plants that are biologically active, protect plants and provide health benefits to the consumer are known as phytochemicals and its secondary metabolites are the antioxidants (Krishnaiah et al. 2007). They have the potential in preventing chronic diseases (Saxena et al. 2013). The phytochemicals include sugars, amino acids, proteins, purines, pyrimidines alkaloids, terpenes and phenolics. Antioxidant compounds of wood apple include carotenoids, flavonoids, cinnamic acids, benzoic acids, folic acid, ascorbic acid and tocopherols (Pandey et al. 2014). The edible parts of wood apple are rich in Phytochemical and Antioxidants the predominant of such compounds are enlisted in Table 2.

Health Benefit of Wood Apple

Wood apple has been used in traditional medicine for about 4000 years in various forms. Fruits, both ripe and unripe, are known to offer medical benefits.

The fruit as a whole has had immense contribution in the field of Ayurveda besides providing nutritional benefits Mani 2020). It is used to treat cardiac debility, wounds, tumours, hepatitis, dysentery, diarrhea, and asthma in the traditional medical system. Additionally, ripe fruit can treat liver and cardiac conditions. It contributes to decreasing blood cholesterol levels (Vidhya and Narain 2017). Tender unmatured fruit is used by rural people for treating cough, sore throat and gums infection since time immemorial. The leaves and trunk latex are used as medicine in Ayurvedic to

Table 2. Some phytochemical and antioxidants contents of wood apple (Compilated by Pandey et al. 2014 and Lamani et al. 2022)

Sl. No	Phytochemical and antioxidant	Quantity	Unit
1.	Alkaloids	36	g.100g^{-1} of dry matter
2.	Saponins	0.16	g.100g^{-1} of dry matter
3.	Total Phenols	35.72	µg GAE.mg^{-1}
4.	flavonoids	35.51	µg GAE.mg^{-1}
5.	β-Carotene	0.04	µg.g^{-1}
6.	ascorbic acid	0.45	µg.g^{-1}
7.	Riboflavin	0.23	µg.g^{-1}
8.	Thiamine	0.31	µg.g^{-1}

treat peptic ulcer or piles pain, discomfort and associated health risks (Vasant and Narasimhacharyaa 2011). The presence of functional, bioactive compounds and antioxidants of wood apple helps against degenerative diseases (Anitha et al. 2015). The methanolic extract of wood apple pulp showed aloft antibacterial activity against *Staphylococcus epidermidis* (25.3 10µ.L-disc), *Staphylococcus aureus* (26.2 10 µ.L-disc) and *Bacillus subtilis* (23.8 10µ.L-disc) (Shipra et al. 2017; Senthilkumar and Venkatesalu 2012). To detoxification through blood purification and elimination of toxins from the body, wood apple juice (50 mg.L^{-1}) mixed with warm water and sugar is advised (Vasant and Narasimhacharyaa 2011).

Anticancer Activity

The human cancer cell line MCF-7 (Michigan Cancer Foundation-7) is inhibited by the essential oils (89.19 g.ml^{-1}) isolated from wood apple leaves due to their cytotoxic and antioxidant characteristics, which cause DNA fragmentation (Thirugnanasampandan and David 2014). Human breast cancer cell lines (SRBR3 and MDA-MBA435) were tested for antineoplastic activity using ethanolic extracts of wood apple fruits, and the effective doses (ED_{50}) were found to be 56.1 and 30.6 g.ml^{-1}, respectively (Pradhan et al. 2012). The in vitro antitumor activity of methanolic extracts of wood apple fruits at oral dose of 570 mg.kg^{-1} body weight on mice model of Dalton's Ascitic Lymphoma (DAL) cell found that treatment with extract enhance nonviable cell counts in peritoneal exudates and decrease the viable cell count which may be because of extract absorption by viable cells and the ultimate results was cell lysis by activation of macrophage or any type of cytokine production (Eluru et al. 2015).

Antidiabetic Activity

On streptozotocin-induced diabetic rats, the anti-diabetic activity of 95% ethanolic extracts of unripe wood apple fruit was assessed at 250 mg.kg^{-1} body weight, and it was discovered that it significantly lowers blood glucose levels in fasted, fed, and streptozotocin-induced diabetic rats (Gupta et al. 2009). In alloxanized diabetic rats, the crude aqueous leaf extract (1 g. kg^{-1} for 30 d) and the leaf alkaloid extract exhibit hypoglycemic action. Aegeline, an alkaloid derived from the leaves of *A. marmelos*, has been shown to have antihyperglycemic and antidyslipidemic effects in animal models of type 2 diabetes mellitus (Gautam

et al. 2015). Fig. 1 shows the overall health benefits of wood apple.

Processing of Wood Apple

Processing of wood apple involves intense labour activity, reason being there exist no any scientific method/ machines for extracting the pulp from the fruit. In case of fully matured ripe the minimum force recorded for rupture was found to be 962.73 N (Murakonda and Dwivedi 2022). The fruit fraction such as shell, pulp, seeds are 47.54 ± 3.99, 41.38 ± 2.96 and

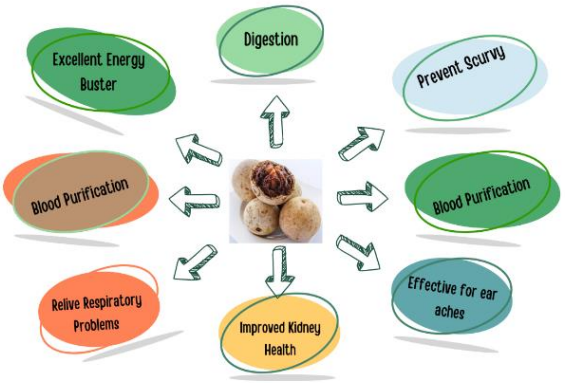

Figure 1. Health benefits of wood apple

11.22 ± 1.2 respectively (Murakonda et al. 2021). Initially the hard-shell outer covering of fruit needs to be broken apart. Then the pulp needs to be scooped out with ladle or spoon. The pulp is also protected with numerous strong fibers and seeds which have to be separated carefully to avoid mixing of pulp and seeds. The complex compound of pulp, seed and fibre has to be mix with pure water in the ratio of 1:1 and Juice can be obtained by centrifuging at 4000 rpm for 10 min with the ratio 1:2 (Singh et al. 2014). Addition of citric acid and lowering the pH to 3.3 during pulp extraction reduces the mucilage holding the pulp and seed (Kamble et al. 2022).

Dried Pulp

It is one of the oldest methods of preserving technology. This technology not only preserves food but also facilitates storage capacity and ease transportation. Time and again this technology has been evolved from simple to advanced high-tech AI assisted dryers. Drying can be carried out in different ways – solar drying, convective hot air oven, Lyophilizer or any other such drying device. Drying of heat-sensitive food materials require low to medium temperature to retain the qualities of the food. In developing countries, solar drying plays a vital role in fulfilling the sustainable energy need, occupying less area and improves product quality (Kumar et al. 2016a). It can be broadly classified according to harnessing of solar power technique into direct, indirect and mixed which have great potential in drying agricultural produce (Mustayen et al. 2014). Conventional hot air drying at low drying rate results in low energy efficiency. Convective hot air oven drying at 70°C and air velocity of 1.5 $m.s^{-1}$ provides the best result in terms of thermal drying of wood apple pulp (Goyary et al. 2021). Freeze dried pulp provides well preserved physicochemical compositions and more consistency in product (Singhania and Ray 2019). In all types of drying methods wood apple pulp can be effectively dried within 5- 6 h of drying, but total polyphenol content retention and antioxidant activity was found to be significantly higher in sun drying process (Vijayakumar et al. 2013). The completely dried pulp is bright yellow to dark yellow in colour with concentrated nutrients.

Tea Like Herbal Hot Drink from Wood Apple

Tea is the hot drink most consumed worldwide liquid after water. 75% of the total tea production is black tea (Pou and Dev 2016). This directly implies that the most drink tea is black. Black tea like drink can also be produced from the tender pulp of wood apple with medicinal benefits. The dried and finely milled wood apple powder can be mixed with curcumin in the ratio of 1:4 to provide best therapeutic valued tea (Minh and Oanh 2018).

Wood apple yogurt. Yoghurt is an important milk product containing health benefits and can be categorized in functional food. The product has characteristic tart flavor and is produced by fermentation action of milk sugar fermenting bacteria such as *Lactobacillus bulgaricus* and *Streptococcus thermophiles* (Goyary et al. 2013; Gustaw et al. 2011). Preparation of functional food is a new trend to inculcate partakes in masses because of its health benefits. Fruits contain probiotic carrier compounds such as phenolic compound, vitamins, bioactive compounds and minerals (Robinson et al. 2006; Sarkar S. 2019). It increases the taste value, texture and mouth feel it

also has significant effect on pH, acidity and syneresis (Vahedi et al. 2008). About 6% addition of wood apple powder to the plain yoghurt enhances the sensorial qualities, 30% reduced calorie and longer shelf-life (Parvin et al. 2019). The product formulation and processing steps of wood apple yoghurt can be followed according to Fig. 2.

Wood Apple Juice and RTS (Ready to Serve)

Fruit juice is the liquid extract of pulp diluted with plain water with some flavor enhancer, stabilizers, regulators, etc. Generally, fruit juice contains 10 to 15% TSS and 3.5 to 4% acid. Numerous types of fruit juices are available commercially now a d it may be solo fruit or mixed fruit. Study of plain wood apple juice showed that it has 9°Brix of TSS and 1.8% acid, RTS has 19% juice, 11.2°Brix TSS and 0.32% acidity which is ideal for both (Zambare et al. 2009).

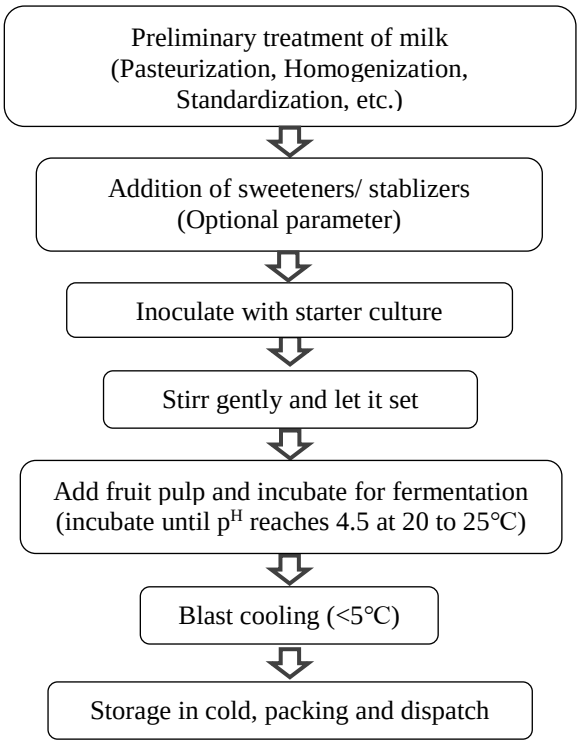

Figure 2. Wood apple yogurt preparation.
*Adapted from Robinson et al. (2006) Copyright 2006, Blackwell Publishing

Wood Apple Wine

Wine is an alcoholic beverage traditionally prepared from fruit juice (grapes). Technically wine contain 5% to 21% alcohol volume by volume, typically fermented with yeast *Saccharomyces cerevisiae*. With the development of novel technologies, it can be prepared from any other fruit juice. Wood apple juice being rich in various nutritional compositions (mainly sugars) and bioactive compounds becomes ideal fruit juice to be fermented and manufactured into wine. The freshly prepared wood apple wine was found that it is rich in antioxidant, good organoleptic score and low alcohol concentration of 7.87% v/v (Panda et al. 2014). Fig. 3 is wood apple wine processing.

Wood Apple Burfi

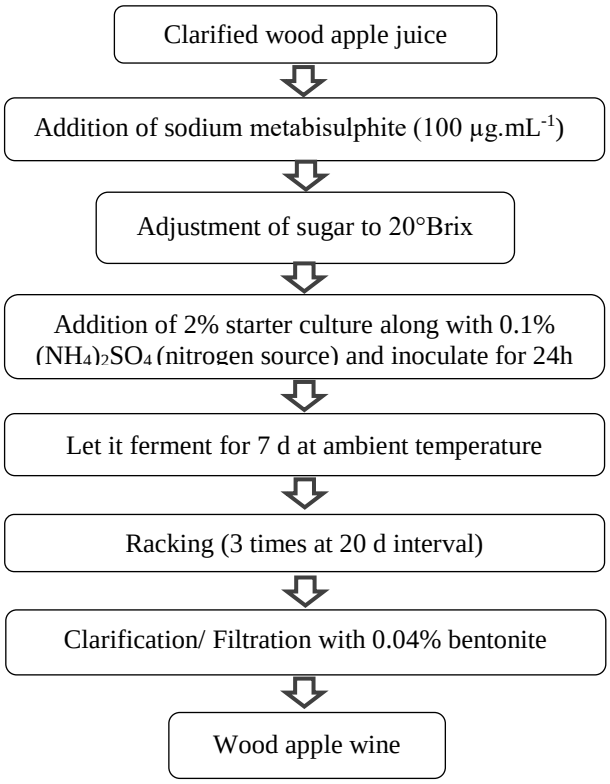

Figure 3. Wood apple wine preparation
*Adapted from Panda et al. (2014) Copyright 2014, Elsevier

Burfi or Borfi or Barfi is an indigenous Indian product typically prepared from dense thick sweetened milk. It can also be prepared by mixing various other ingredients into the milk or water in appropriate proportion. Commercially available burfi includes coconut burfi, Kaju (Cashew nut) Burfi, Pineapple flavored burfi etc. Coconut burfi is made by mixing and heating finely grinded coconut

with sugar, ghee and cardamom powder (Gupta et al. 2010). Pineapple flavored burfi can be made by adding 10 parts of pulp extract in 90 parts of khoya (Bankar et al. 2013). Wood apple can be incorporated in partially dehydrated whole milk and blended in burfi (Navale et al. 2014). About 20% addition of wood apple pulp provides high acceptance score in terms of flavor, organoleptic, sensorial property (Giri et al. 2013).

Kulfi

Kulfi is a frozen milk product containing 36% total solids, 10% fat, 3.5% protein and 0.5% stabilizer. The overall meltdown time of kulfi should be an hour to hour and half in case of controlled samples (Kumar et al. 2016b). It can be prepared by substitution of ingredients also. Sunflower vegetable oil can be substituted up to 70% of the total fat of kulfi without affecting its quality (Murthy et al. 2009). Incorporation of 3%whey protein concentrate increases the nutritional as well as calorific value of kulfi (Sarkar 2019).

Wood Apple Kalakand

Kalakand is an Indian traditional sweet prepared from sweetened semi-solidified milk (channa) having appetizing caramelized flavor and slightly granular in texture. To make the product more attractive, more palatable and attract more consumers' producers incorporate various fruit extract, flavor, etc in the product. About 15% wood apple pulp, 85% buffalo milk channa and 30% sugar of the total weight makes kalak and a nutritional rich product possessing therapeutic value (Kumar and Singh 2017).

Wood Apple Jam and Jelly

Jam and Jelly are those confectionaries that have almost same type of specifications but differ in their processing ingredients. Jam is prepared with whole fruit pulp whereas Jelly is prepared with extracted clarified fruit juice. There is no particularity of raw materials for making jam and jelly. They can be made with any edible fruit. According to Food Safety and Standard Authority (FSSAI) typically Jam must contain minimum of 45% pulp, 65% total soluble solids (TSS) and 40 ppm preservative and jelly must contain minimum of 45% juice extract, 65% total soluble solids (TSS) and 40 ppm preservative. Jelly must hold itself and jam takes the shape of vessel where it is kept. 25% of wood apple extract with 75% water can produce high organoleptic quality jelly (Kumar and Deen 2017). Pulp and seed can be separated by reducing the mucilage and wholly prepared by adding water in the ratio of 1:1. The process flow chart of Jam and Jelly are alike in all steps other than initial raw materials; combined process flow chart is shown in Fig. 4.

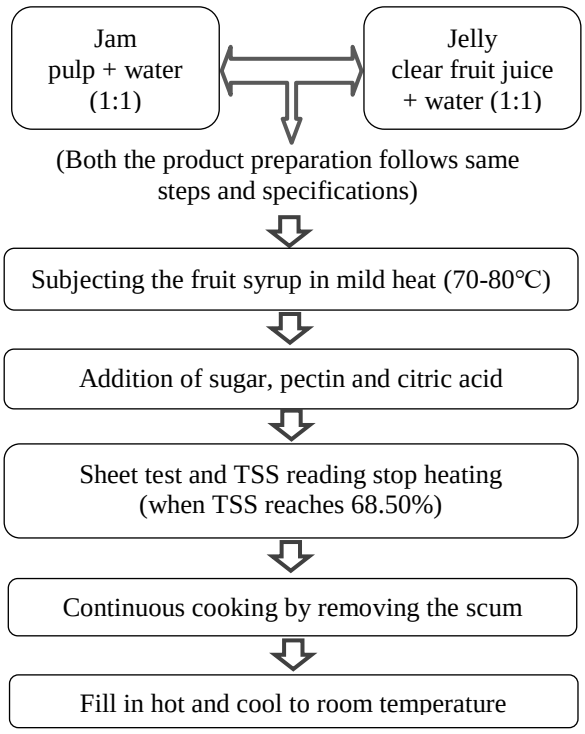

Figure 4. Wood apple jam and jelly preparation. *Adapted from Kumar and Deen (2017) Copyright 2017, Society of Pharmacognosy and Phytochemistry

Wood Apple Fruit Bar

Fruit bar is a partially dehydrated (a_w = 0.36 to 0.55) nutritionally rich product containing dietary fiber and natural sugars. It is an ultimate source of bioactive factors as they are preserved in fruit bars hence their take-up utilization makes a positive difference in consumers' health (Orrego et al. 2014).

Wood Apple Preserve and Candy

Preserve and Candy are concentrated fruit products having fruit pulp of at least 55% and citric acid 1% to 1.5%. According to Food Safety and Standard Authority (FSSAI) technically preserve should have 70% and Candy should have 75% TSS. For both products the main preserving agent is sugar. They are simple products and were processed since time immemorial. Due to minimal processing complexities almost all types of beneficial nutrients are preserved. Properly packed product shelf increases to several months or a year. The process of wood apple candy is shown on Fig. 5.

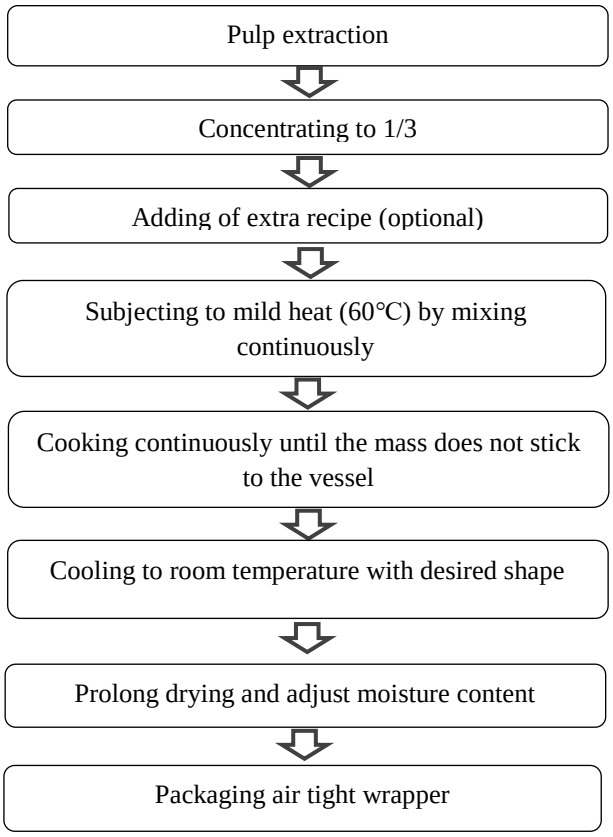

Figure 5. Wood apple candy processing.
*Adapted from Singh et al. (2017) Copyright 2017, Universiti Putra Malaysia

Pickle

Pickle is the Indian centuries old preservative technique. Fermentation is the prime activity in preparation of pickle. According to Food Safety and Standard Authority (FSSAI) typically pickle should contain drain weight 60%, sodium chloride 12%, acidity 1.2% and preservative (SO_2) 100 ppm. Wood apple pulp pickle possessed more nutritive values than the raw one, reason may be due to biochemical change during fermentation (Rathore et al. 2021).

Conclusions

The value-added products of wood apple are aidful and have positive impact to health. Uptake of these products is advisable due to the fact that the beneficial components/ nutrients of fruits remain intact with the processed food. The wood apple products discussed in this paper have a far greater nutritional value than the fresh ones because all nutrients get concentrated during processing. Due to presence of such a high value component the fruit is sometimes called as 'Miracle fruit'. Convenience food processed from wood apple pulp will have wonderful assortment of therapeutic values, antioxidant and antimicrobial activities.

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