



Historical Background, Origin, Distribution & Present Status of Wood Apple

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Authors' contributions

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

Article Information

DOI: <https://doi.org/10.9734/jabb/2024/v27i101566>

Open Peer Review History:

This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: <https://www.sdiarticle5.com/review-history/124320>

Review Article

Received: 08/08/2024

Accepted: 15/10/2024

Published: 24/10/2024

ABSTRACT

Wood apple (*Feronia limonia* L.; Rutaceae family) commonly known as poor man's fruit in India due to its several nutraceutical importance, is native to South India and Sri Lanka. Sanskrit term, "kapittha," receives several mentions in a number of ancient texts including "Hinduism: an Alphabetical Guide". Buddhist scholar mentioned wood apple as an Indian fruit while, military commander and poet *Chauvundaraya* (940-989AD) listed wood apple in numerous medicinal remedies and also mentioned in *Charak Samhita* and *Sushruta Samhita*. Wood apple has been planted extensively or being allowed to grow naturally in the reserved forests throughout Southeast Asia, Northern Malaysia and on Penang Island. In India, it is more common in Deccan,

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Cite as: Shukla, Usha, Rubee Lata, Sutanu Maji, Razauddin, and Ramesh Chand Meena. 2024. "Historical Background, Origin, Distribution & Present Status of Wood Apple". *Journal of Advances in Biology & Biotechnology* 27 (10):1457-67. <https://doi.org/10.9734/jabb/2024/v27i101566>.

Maharashtra, Madhya Pradesh, Uttar Pradesh, Chhatisgarh, Bihar, Jharkhand, West Bengal, Rajasthan, Gujarat, Tamil Nadu, Andhra Pradesh, Kerala and Odisha, however, no data is available for its area and production. Unfortunately, the lack of attention has meant that their potential value is under-exploited and they are in danger of continued genetic erosion, ultimately leading to disappearance. Therefore, it is necessary to spread the awareness of its importance among common people and researches to identify superior genotypes, production problems of wood apple for their ex-situ collection, conservation, evaluation and utilization that is being explained by this study after having various literatures available in different forms from different sources. This review article will help future researchers to conserve as well as explore the possible benefits of this crop to the common people harnessing societal value of growers.

Keywords: Underutilized fruits; nutraceutical; genotypes; conserve and Ex-situ.

1. INTRODUCTION

Wood apple is a thorny tree and most common underutilized fruit crop in India. It belongs to the family Rutaceae and is botanically known as *Feronia* (*F. limonia* L.) [1]. In India, wood apple fruit was traditionally known as a "poor man's food" until processing techniques were developed in the mid 1950s [2]. The genus *Feronia* is assigned to the tree in the honor of Roman Goddess of forest [3]. In addition to wood apple, it is also referred to as elephant apple or monkey fruit since elephants enjoy it. Other frequent names for wood apples include "curd apple," "golden apple," "stone apple," and so forth; these names are typically depending on language, location, and culture [4, 5]. The people living in rural areas think that the animal's digestive system possesses a unique ability to break down the fruit's insides without compromising the fruit's outer hard texture. As a result, the fruit appears entire when the animal excretes.

Other dialectal names in Thailand as *ma-khwit*, as *Kramsang* in Cambodia; as *Ma-fi* in Laos; as *Gelinggai* or *Belinggai* in Malaysia, as *pomme d'elept*, *hanpomme de bois* or *citron des mois* in French [6] as *Tuffâhh elfil* in Arabic, as *Kathbel* in Bangladesh, as *Thibin*, *Thanaka*, *tha nap-hka* in Burmese, as *mu ping guo*, *mu ping kuo* in Chinese, as *elefantæble* in Danish, as *olifants apple* in Dutch as *kabeet*, *kabut* in Fiji, as *vellampelam*, *Vakandra* in Hindu and as *Elefantenapfel* in German [7].

In India, it is known differently in different languages such as Kayatbael, Kavataleal, Kavita in Bengali, Askotha, Kondhu in Gujrati, as Kaitha in Hindi, as Kavatha in Marathi, as Vilamaram, Vilangai in Tamil and as Kaith in Urdu etc. [8].

The wood apple is a tropical tree. It is one of the hardiest fruits grown in semi-arid and arid

regions, excluding high altitude and cold region of India. Fruit has an acidic nature when unripe condition but, gives pleasant flavour when ripe [9]. This deciduous tree has globose, orange-sized fruits with a stiff, woody rind, and strangely pinnate leaves. One of the common hard-shelled citrus fruits, it is a member of the orange subfamily Citratae of the Rutaceae family, which also includes the genera *Feroniella*, *Aegle*, *Chaetospermum*, *Balsamocitrus*, and *Aeglopsis*. The wood apple trees can be grown successfully in areas which receiving mean annual rainfall 25-60 cm and mean annual temperature 20-35°C. The wood apple is generally grown from seeds and seed germinate within 7-14 days after sowing but seedlings require at least 8-10 years to bear fruits therefore, its propagation is commercially done by grafting and budding for precociousness. Tree planting is done usually in rainy season but if irrigation facility is available then planting is advisable during February-March due to its peak growing period. Grafted plant should be planted at 8 m x 5 m spacing for better yield [10].

Wood apples are an inexpensive, incredibly nutrient-dense, readily perishable, and seasonally available fruit that can be preserved all year round for human use as processed goods like jam, chutney, and jelly [11]. In Ayurveda, it is highly prized for its therapeutic properties and is said to treat respiratory issues, piles, diarrhea, dysentery, and liver ailments. Wood apple juice has exceptional thirst-quench properties and has great potential to become a major crop in the beverage production industry. In Indian households, wood apples are traditionally eaten raw due to its exceptional flavor and ideal balance of tart and sweetness. The majority of the tree's parts are utilized to make herbal remedies. The roots can be used to treat dyspepsia, diarrhea, and dysentery. Aqueous preparations of the stem and root bark

are applied topically to heal eczema, urticaria, malaria, fever, and jaundice. Fruit extract has cholesterol-lowering potential, used in the treatment of diarrhea and dysentery. Several microbes responsible for human diseases exhibit resistance to essential oils derived from wood apple fruits [12], can be used to cure ear conditions such as earaches etc. [1]. Wood apple fruit pulp can reduce lipid profiles and hepatic glucose-6-phosphatase levels, along with a significant increase in hepatic glycogen, hexokinase, and HDL [13]. Fruit extracts shows inhibitory effects against *C. albicans*, *A. tumefaciens*, *B. subtilis*, *P. fluorescens* and *Escherichia coli* [14]. It also shows anti-cancer properties [15]. The fruit and root demonstrated antiamebic and hypoglycemic properties in pharmacological trials. Alkaloids abound in the plant, with Aegline, Marmesin, Marmin, and Marmelosin (Marmelosin also called as imperatorin, is a major chemical constituent of wood apple has an anticancer, antibacterial and anti-inflammatory activity [16] being the main ones. Luvangetin and pyranocoumarin, which were extracted from seeds, had noteworthy antiulcer properties. The leaf's essential oil possesses antifungal properties [17]. The leaves smell like anise and are fed to cattle.

Timber is used to make household items, small tools for agriculture, and house construction. From the seeds of the wood apple (*Limonia acidissima*), protein concentrate and protein isolate were prepared, along with seed flour. Protein isolate had the highest protein content (85.93%) compared to protein concentrate (76.50%) and wood apple seed flour (27.56%). However, flour, protein concentrate, and protein isolates of wood apple seed had higher concentrations of the essential amino acids (Histisine, Threonine, Valine, Leucine, Isoleucine, and Lysine) of the protein [18]. Additionally, it is stated that the protein concentrate, isolate, and flour from wood apple seeds were found to be nutritionally equivalent to other oilseed flours and may find application in the creation of additional food formulations. Activated carbon with the highest surface area and the most developed micro, meso, and macroporosity is produced from the woodapple shell using the $ZnCl_2$ carbonization process and activation at 800°C in a nitrogen atmosphere

(925 m²/g) [19]. The fruit's rind is so thick and hard that it can be carved to resemble a bowl or ashtray. Hard wood from the tree is useful for woodworking. Timber is utilized in the building of hubs, houses, posts, mill rollers, and farm equipment. The wood is also used as fuel. For fodder, the leaves are clipped. Because of its water tolerance, the plant has also been used as citrus rootstock in Thailand. Additionally, the bark yields an edible gum. A bland, non-bitter oil rich in unsaturated fatty acids can be found in seeds [7]. The wood is hard, heavy, durable, and yellow-grey or whitish. A white, transparent gum that is exuded from the trunk and branches is used as an adulterant or replacement for gum arabic. In addition, artists' watercolors, ink, dyes, and varnish are made from gum. The gum is made up of 42.7% d-galactose, 35.5% arabinose and xylose, and trace amounts of rhamnose and glucuronic acid.

Wood apple contains phytochemicals like polyphenols, vitamins, saponins, coumarins, amino acids, tri-terpenoids, phytosterols and tannins [20]. Phytochemical analysis of *Limonia acidissima* ripe fruits indicates presence of flavonoids, steroids, glycosides and various acidic compounds. The major chemical compounds in leaf are acidissimin and acidissiminol. Presence of alkaloids, phenols resins, gum and mucilage, fixed oils and fats are also noted in leaves [21]. The wood apple pulp is very good source of carbohydrates (70.14%), protein (13.8%), fat (4.3%) and dietary fibre (1.7%) [20, 22]. Presence of low amount of fat (4.38%), calcium, magnesium, iron, and high amounts of zinc are also reported in this fruit. High amount of phosphorous and calcium are also found out that exerts vital role in bone formation, blood clotting and more other metabolic processes. The presence of iron in fruit indicates effectiveness against anemia, tuberculosis and other disorders [23]. The detail nutritional composition of wood apple fruit has been presented in Table1.

The wood apple (*Feronia limonia* Swingle) is the only species of the genus. The other species viz., *F. elephantumcorrea*, *Limonia acidissima* L., *Schinus limonia* L., are considered as synonymous to *Feronia lemonias* Swingle, now named as *Feronia* or *Limonia limonia* [25].

Table 1. Nutritional composition of wood apple fruit

Fruit part	Components found						
Wood apple fruit pulp	Ash	0.89 – 2.73 %	Moisture	64-74.03 %	Crude fiber	3.32 %	
	Total sugar	31.59 %	Fructose	16.40 %	Glucose	14.23 %	
	Rhamnose	0.24 %	Sucrose	0.13 %	Maltose	0.57 %	
	Reducing sugar	1.04–4.09 %	Mono saturated fatty acids	26.20 %	Poly unsaturated fatty acids	25.78 %	
	α -linolenic acid	16.55 %	Riboflavin	170 mg	Phosphorus	0.08 mg	
	Iron	0.07–0.48 mg	Calcium	0.17 mg	Phosphorus	46.5–110 mg	
	Iron	3.5 mg	Sodium	8.5 mg	Zinc	386.3 mg	
	Copper	0.8 mg	Manganese	0.7 mg			
	Trace amount of amino acids - arginine, histidine, isoleucine, glycine, leucine, tyrosine, methionine, glutamic acid, proline, valine, serine, threonine, tryptophan and phenylalanine						
	Wood apple pulp oil	Linoleic acid- 10.02 %					

Adopted from Sharma et al. [24]

Taxonomy of wood apple:

Kingdom:	Plantae
Sub-kingdom:	Tracheobionta
Super division:	Spermatophyta
Division:	Magnoliophyta
Class:	Magnolipsida
Subclass:	Rosidae
Order:	Sapindales
Family:	Rutaceae
Genus:	<i>Feronia</i>
Species:	<i>Limonia</i>

Source- (Bhandari, 1978)

Synonyms: *Feronia elephantum* Correa, *Feronia limonia* (L.) Swingle, *Schinus limonia* L. *Crateva balangas* K.D.Koenig, *C. vallanga* J.Koenig ex Wight & Arn., *Anisifolium curvispina* (Miq.) Kuntze, *A. limonia* Kuntze, *A. spectabile* (Miq.) Kuntze, *Feronia balanghas* (K.D.Koenig) Steud., *Hesperethusa acidissima* (L.) M.Roem., *H. ambigua* M.Roem., *Limonia ambigua* DC., *L. curvispina* Miq., *L. dulcis* J.F.Gmel., *L. elephantum* (Corrêa) Panigrahi, *L. engleriana* Perkins, *L. pinnatifolia* Houtt., *L. spectabilis* Miq., *Murraya odorata* Blanco [26].

For the impoverished, wood apples can be vital to their security of food and means of subsistence. These plants run the risk of becoming neglected, but they frequently contribute significantly to rural communities' cultures, means of subsistence and ability to generate income. Sadly, because of the neglect, their potential value has not been fully realized and they run the risk of continuing to lose genetic diversity, which could eventually cause them to become extinct.

History: Because wood apple is sometimes referred to as "bael," which may also refer to a fruit that is similar (*Aegle marmelos*), its history is a little hazy. Nonetheless, the Sanskrit word for wood apple, "kapittha," appears multiple times in various ancient writings [27]. The wood apple seed was compared to a great cosmic egg that held the origin of creation in the Puranas, Sanskrit texts written between 1 BC and 1,000 AD, according to the book "Hinduism: an Alphabetical Guide." The wood apple was identified as an Indian fruit by Buddhist scholar Xuanzang (602 and 664 AD), and military leader and poet Chauvundaraya (940–9889 AD) included wood apple in a long list of medicinal uses [28]. Wood apple has been used as medicine since ancient times and is mentioned in two early Sanskrit medical tracts, the Sushruta Samhita (6th century BC) and the Charak Samhita (written by Maharshi Charak) [29]. Fruits are used as the only or a contributing ingredient in ayurvedic medicines [30], adding significant nutritional and commercial value [31]. Hindus regard it as sacred. Though not grown for commercial purposes, it is revered in Southern India, particularly around the Ganesh Chaturthi celebration [29]. Its fruits are also used to pray the Hindu Elephant-headed God, Lord Vinayaka, and therefore, it is extensively grown near the Lord Ganesh temple all over the country [6]. Wood apple finds a mention in the Yajurveda. It has been mentioned in writings dating back to 800 B.C. In Dharma sutras and Saiva Upanishads Shriphala/Sriphala in Sanskrit means the fruit of plenty. As the tree is affiliated with Lakshmi it is also called Sri-vrksha -the tree of prosperity and good fortune. Since the Ancient

time it has a great cultural, socio-economic and religious significance in India.

The wood-apple was first given a binomial name by Linnaeus in 1753 as *Schinus limonia*, with citation to a rather full description drawn up by Linnaeus himself and published, in 1747, in his account of Hermann's herbarium of Ceylonese plants. Four citations are given under *Limonia acidissima*. The first is to Burman's Thesaurus Zeylanicus, which includes two or more species, one of them being very probably the common lime *Citrus aurantifolia* (Christm.) Swing. The second citation is to his own Flora Zeylanica and certainly applies to the wood-apple. The third citation is to Rumphius Herbarium Amboinense, which is also the wood-apple or a closely allied species. The fourth citation is to Rheede, Hortus Malabaricus, and is *Hesperethus acrenulata* (Roxb.) Roem. *Limonia* then being invalid, the next oldest generic name must be taken up. This is *Feronia*, published by Corrêa in 1800, the name now commonly used. Since the wood-apple was first published as *Schinus limonia* by Linnaeus in 1753, the oldest valid name of the wood-apple is *Feronia limonia* (L.) n. comb. Wood apple (*Limonia acidissima* L.) is one of the lesser known fruit like Roktogota (*Haematocarpus validus*) in Bangladesh [31].

Origin and Distribution: South India and Sri Lanka are the original home of the wood apple [32]. The wood apple is native to and widely grown in the arid plains of Bangladesh and Pakistan [33]; it is also grown in Ceylon and India [18].

The wood apple is range from Indo-China and the Philippine Islands to West Africa. It is also grown throughout Southeast Asia, Northern Malaysia and on Penang Island [4]. It is grown beside roads, on the edges of fields, and sometimes in orchards in Sri Lanka and India. It is grown in parks and villages in Malaysia and Indonesia.

In the western Himalayas, the tree may grow to a height of 450 meters above mean sea level (MSL) [34] as well as at western Ghats spread with rich biodiversity heritage in Eastern Parts [33]. It grows best in light soils and appears to be drought tolerant.

It is a rare phenomenon to find a well planted wood apple orchard in India. The information regarding area and production under this fruit crop in India are not available. Generally scattered trees are found in forests, community

land on field bunds and road sides or in a homestead garden. The tree is commonly grown as a border plant in addition to being found in jungles. According to Veeraraghavathatham *et al.* [35], this tree is perfect for cultivation along roads, field borders, and occasionally orchards. Wastelands common in wild, dry plains are good places for it to grow. It is distributed in the Alavallis of south east Rajasthan in India. It is more common in Deccan, Maharashtra, Madhya Pradesh, Uttar Pradesh, Chhatisgarh, Bihar, Jharkhand, West Bengal, Rajasthan, Gujrat, Tamilnadu, Andhra Pradesh, Kerala and Odisha.

It grows in the western Himalayas in both wild and cultivated forms up to an elevation of 1500 feet; in Maharashtra, it is most prevalent in the Deccan, Thane, and Chandrapur districts. Additionally, it is said to exist in some areas of Jharkhand's Hazaribagh, Palamau, and Chota Nagpur as well as in the Vidhyan hills of Uttar Pradesh and Chattisgarh's forests.

In Uttar Pradesh it is scattered in many districts such as Hardoi, Sitapur, Ayodhya, Bahraich, Gonda, Barabanki, Lucknow, Kushinagar, Etawah and Kanpur [36]. Wood apple of Gazipur and Rajshahi area are fairly large [6]. Although less used, the Bundelkhand region of India has a high biodiversity for wood apples. Bundelkhand's agroclimatic conditions hold great promise for its commercial cultivation [37]. Fruits from wood apple trees were harvested in Milkipur Tehsil, Faizabad, specifically from Ratapur village [38]. The Hardoi districts of Uttar Pradesh (U.P., India) local market provided fresh harvested wood apple fruit [5].

The genotype diversity of wood apple is highest in the semi-arid lateritic belt of West Bengal. By Dowarah *et al.* [31], the diversity-rich wood apple district has been studied and fruits of twelve distinct genotypes have been collected from diverse villages in different blocks, including Makarampur, Raipur, Surul, Ruppur, Bahadurpur, Ballavpur, and Sahebanga. In the Nadia district of West Bengal, a preliminary survey was conducted to identify and choose twenty trees from various locations. In Shantipur, Gede, Kalyani, Krishnanagar, Karimpur, Haringhata, Ranaghat, Nabadwip, Chakdah, and Palashi, final studies on the top ten accessions were conducted [12]. Wood apple is such an underutilized fruit, largely grown, rather seen mostly in eastern part of the state of Odisha [39].

In Tamil Nadu, wood apples are traditionally grown as a commercial crop under dry land

horticulture and as a holistic fruit tree. In Chennai, wood apple trees are widely distributed and can be found growing naturally in the grounds of some residential bungalows and institutions, or they can be planted at the homestead level [28]. More than thousands of wood apple trees were observed during a study of the sustainable production of wood apples in line with current research findings. These trees were found along roads, the edges of fields, and occasionally in orchards in the districts of Salem and Krishnagiri. Since it is a fruit of wild trees, numerous trees have been seen in the districts of Salem, Dharmapuri, Namakkal, Krishnagiri, and Coimbatore colleges and universities.

According to Sridhar *et al.* [3], 86 genotypes were chosen from various Karnataka locations for the survey work like from Taradhalli Balekoppa, Mallavali, Kanakapur, Mallapur,

Dupdhal, Tatur Jcpura and Maradur, Chitrahalli and Allur, Devarhipargi, Honalli cross, Ecchalgata and Ramanhalli. Dwarahalli, Godachi, Eleven Hanumanhalli and Bellar farm.

The majority of wood apple seedlings are found growing naturally in isolated or dispersed locations throughout Gujarat, India's different agroclimatic zones. Because of the enormous genetic diversity in the surviving populations, there is a strong likelihood that better genotypes will be selected [40].

Present Status of wood apple: Basically it is cultivated in Indian states like Maharashtra, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Madhya Pradesh, and the western Himalayas, it is primarily native to India but is also found in Sri Lanka, Nepal, Malaysia, Cambodia, Thailand, Africa, and other parts of southern Asia.

South India, Sri Lanka, Nepal Bangladesh Pakistan, Indo-China, Philippine Islands to West Africa, Northern Malaysia, Indonesia and Western Himalaya regions



Fig. 1. Distribution of wood apple in world

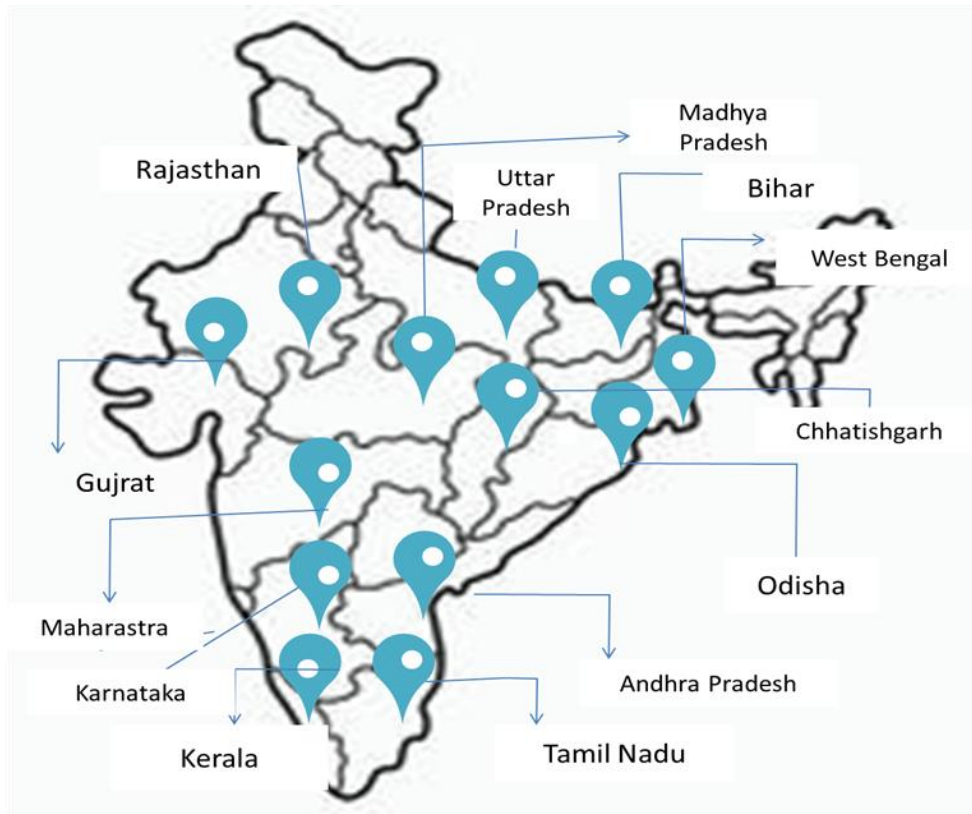


Fig. 2. Distribution of wood apple in India

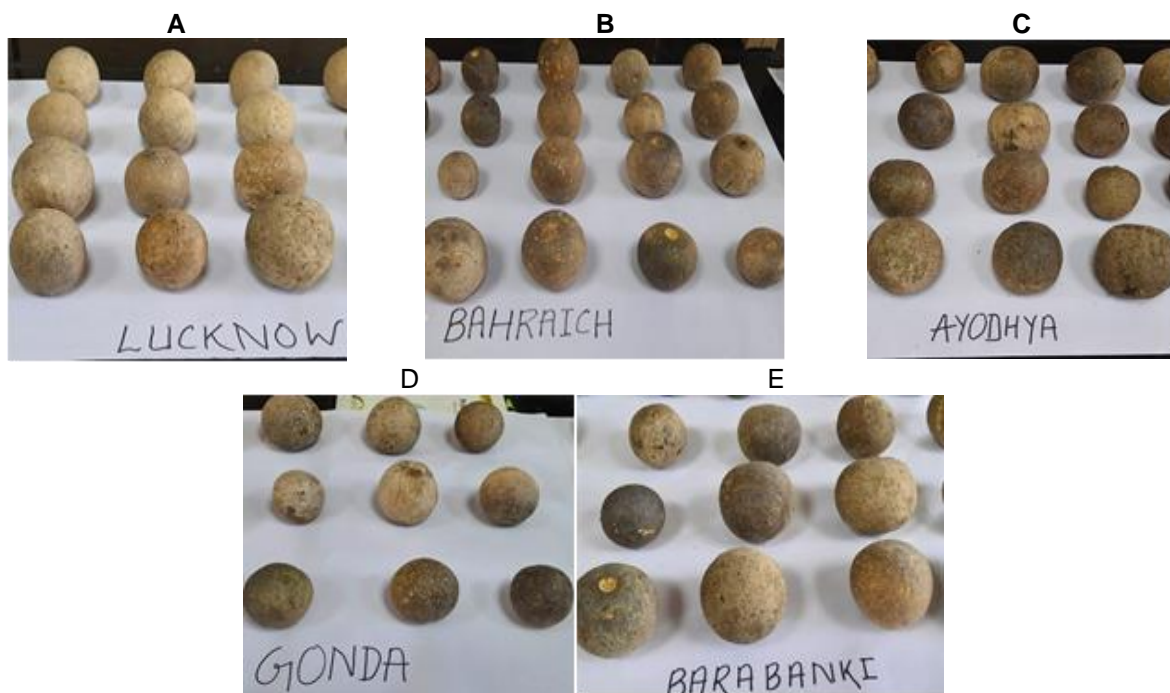


Fig. 3. Variability found in fruits of wood apple collected from various location of Uttar Pradesh

A[Lucknow], B[Bahraich], C[Ayodhya], D[Gonda] and E[Barabanki]

The wood apple variety "Thar Gaurav" was originated at the Central Horticultural Experiment Station, a regional center in Godhra, and it was released by ICAR-CIAH in 2019. This variety is suitable to grow under stress conditions (moisture and temperature). Its growth habit is spreading, having drooping branches. Fruits mature after 230 days after fruit set. The fruit shape is oblong, colour is greenish-white and pulp colour is brownish. Fruits are rich in pectin and protein content. The fruit weight is about 452.25 g, fruit size having 103.67 x 96.66mm dimension, 50.92 % pulp, 180.12 g shell weight, 14.12 °Brix TSS, 3.85% acidity, 3.07% total sugar, 1.42% reducing sugar, 1.76 % fruit pectin, 18.13 % fruit protein, 24.38% seed protein, phosphorous 0.07%, potassium 1.73%, calcium 0.30% and iron 16.72 mg [41].

Large numbers of germplasm were established in field gene bank of the institution, after evaluation, variety Thar Prabha was developed to provide prosperity and nutritional security to resource poor farmers of dry land areas of the country. It was developed through selection method. This selection was collected from Bhopal district of Madhya Pradesh in 2005 and established through softwood in-situ grafting under field condition [42]. Tribal people in Madhya Pradesh's Rewa District also use fruit pulp as a treatment for amoebiasis and boils [43].

The varieties of wood apple like Dharwad Selection-1, Dharwad Selection-2 have been developed by UAS, Dharwad which are superior type for fruit production under dry land conditions. Yellora variety was released by Vasant Rao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra in 1986. The tree shows semi-spreading growth habits. The fruits are green and round in shape with large size (350.0g). It is regular bearer and also suitable for dry land condition. The plants are propagated commercially through soft wood grafting. The fruits are mature in December month and give 250-350 fruits per plants [44].

To identify the elite wood apple germplasm within its natural population from various sites within West Bengal's Nadia district, a study has been carried out. Ten high-quality germplasm samples have been selected for in-depth research on fruiting, flowering, and fruit biochemical properties after wood apple trees in 20 distinct locations were first screened for fruit quality characteristics [29]. The National

Herbarium of Cultivated Plants (NHCP) now has two new wood apple germplasm additions [45].

For centuries, Burmese women and girls in Myanmar have used the finely ground bark of the Thanaka tree to create a skin-protecting and beautifying cream known as Thanaka. All Myanmar markets sell the gold-colored Thanaka, which is used by both young and old. The natural components of Thanaka minimize moisture loss and assist the skin's defense mechanisms against damaging UV radiation [46].

In the city of Rembang in Central Java, Buah Kawista is famously processed into a sticky, brown syrup known as Kawis syrup. Buah Kawista is considered a rare fruit in the rest of Indonesia and has been processed into syrup in Rembang since 1925, sold as a favored souvenir. Wood apple rasamor Vizham Pazham, it can be served as Rasam as well as a soup [47].

Recently, wood apple has grown in significance as a commodity in Sri Lanka's economy. Fruit pulp is used to make wood apple cream, which is then canned and exported [48]. In Thailand, fresh fruits, tender shoots, and young leaves are also consumed. The jelly has a purple color and resembles black currant jelly [49]. Because of its tolerance to water, the plant has also been used as rootstock for citrus in Thailand [50-54].

2. CONCLUSION

From the above study of various journals books, review papers, research papers, it is quit established that wood apple has potential nutraceutical benefits to the mankind. The fruits can be use for many purposes like fresh consumption processed products of commercial importance. There is a good diversity of wood apple in various parts of India as well as world. However, this article reflects the lack of research for conservation, crop improvement and commercial production. Some schemes may be undertaken by the government or associated organization to popularized wood apple by means of production of value added products, bi products, special initiatives to conserve desirable genotypes, production of low cost quality planting materials and distributed to the common people, standardized packages and practices and conducting awareness programs. The present manuscript is emphasizing proximate analysis, diversity in germplasm, historical

background, diversity areas etc can be helpful to the future researchers for the overall improvement of wood apple cultivation.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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