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RESEARCH ARTICLE

WOODAPPLE CULTIVATION IN INDIA: NEED OF THE HOUR FOR MAKING AGRICULTURE UP-TO-DATE AND MORE EARNING ORIENTED

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ABSTRACT

Wood Apple scientifically known as Feronia limonia or Limonia acidissima, is an underutilized dry land fruit crop and also known by vernacular names like kaitha, kainth bel, kothbel and monkory fruits. It belongs to family Rutaceae. In India, it is consumed either raw or ripe. Growing habits are deciduous, erect (seedling plant), and spreading (grafted plant). It has a strong root system, making it drought resilient, and it prefers light to heavy soil. The fruits of the wood apple tree have curative characteristics, making it one of India's most beneficial medicinal plants. It contains nutritious and therapeutic value, as well as astringent characteristics and a role in the cardiovascular system.The lesser known fruit crop wood apple is native to India but is also found in Sri Lanka, Malaysia, Cambodia, Thailand and other regions in the southern part of Asia. It is considered sacred by Hindus. It is not cultivated as commercial crop but it has religious importance in Southern India especially during Ganesh Chaturthi festival. Fruits contribute important nutritional and commercial value from the ancient time is being used in ayurvedic medicines as sole or contributing ingredient, but there is lack of published works in terms of depth scientific investigations about the fruit. The wood apple tree is locally known as elephant apple, monkey fruit, curd fruit, kata and kaithbel in different part of the country. It is native to south India and grows naturally in scattered manner in dry land and forest area in all parts of the country excluding high altitude and in cold region. It prefers dry hot condition at flowering and fruit setting stage. The tree is tolerant to both drought and waterlogging condition. The mature fruit have creamy-brownish, sticky, resinous, astringent, acidic-sweet pulp. The fruit pulp has pleasant aroma and seed scattered throughout fruit. The fruit and plant parts (leaf, stem, bark, fruit and seed) have good medicinal and curative values.

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INTRODUCTION

Wood apple *Feronialimonia L.* Family: Rutaceae Wood apple, a native of India and Sri Lanka is one of the hardy trees of arid and semi arid regions. The fruit is a hard- shelled many seeded berry with its pinkish brown aromatic soursweet pulp being the edible portion the seeds embedded in it. Wood apple is Botanically known as Limonia acidissima**,** The fruit shells are tough, and the inside is brownish pulp and small white seeds. The pulp can be eaten raw, but it is popularly scooped out and frozen, or made into jam. It can also be mixed with coconut milk for a delicious, healthy beverage, or frozen into ice cream. Aegle marmelos, commonly known as bael (or bili or bhel), also Bengal quince, golden apple, Japanese bitter orange, stone apple or wood apple, is a species of tree native to the Indian subcontinent and Southeast Asia. It is present in India, Pakistan, Bangladesh, Sri Lanka, and Nepal as a naturalized species. The tree is considered to be sacred by Hindus and Buddhists. Wood apples are safe for everyday consumption. Thiamine and riboflavin, both found in abundance in wood apple, have powerful detoxifying effects.

Wood apple juice is beneficial for general digestive health and for preventing and treating renal issues. The bael tree (Aegle marmelos), which originates in India and Southeast Asia, produces a fruit called bael, which is both sweet and fragrant. The fruit can be consumed in its various forms, including fresh, dried, and juice. Some people believe that by eating bael fruit, you can remedy health problems including indigestion. Besides its native India, Sri Lanka, and Thailand also cultivate substantial amounts of wood apple fruit for their local markets. The interior resembles banana pudding, with a dark brown pulp and sticky, hairy seeds. Its sour taste makes it a favourite addition to sweet condiments like chutneys and jams. Wood apples are cherished for both their tasty flavour and their beneficial nutritional content. The ball-like fruits grow on deciduous trees reaching up to nine meters in height and have historically been used as a food source and medicinal ingredient throughout India and Sri Lanka. Wood apples have also been introduced to other regions in Southeast Asia, where the tree is planted as a novelty in public landscapes or home gardens. Wood apples are primarily wild and have not been selected for commercial cultivation. There are many varieties of Wood apples generally labeled Wood apple in fresh markets, and

these cultivars are divided using two main categories, varying by size. Larger Wood apple varieties are the most common in markets as they are valued for their sweeter flavor. Smaller varieties are acidic and sour, making them less desired for culinary preparations. Wood apples are known by many regional names, including Elephant apples, Monkey fruit, Kaith in Hindi, Katbel in Bengali. It is important to note that Wood apples are sometimes confused with bael fruit and may be called bael in some markets, but the two fruits are different species and should not be considered the same. In the modern day, Wood apple trees are in threat of becoming an endangered species, as the wild trees are being cut down without replanting, and the fruits are being foraged unsustainably for sale in markets. When available, Wood apples are consumed fresh or cooked and are also incorporated into Ayurvedic practices as a natural medicine.

Wood apple Tree

Origin and Distribution: Maharashtra is the largest producer of wood apple in India. In India, it is cultivated in the states such as Maharashtra, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Karnataka, Kerala and certain regions of Western Himalayas. Wood apple is reported to be native of South India. The plants is seen to be distributed throughout the tropical and subtropical regions of the world particularly in India, Myanmar, Thailand, Indonesia, Cambodia, Pakistan and Nepal. Wood apple occurs naturally in India, Sri Lanka, Burma and Indo-China, where it is limited to the drier regions. It is cultivated in villages and parks throughout its natural range, and in Malaysia and Indonesia (Java, Bali) where it has even become naturalized (western Java). It was introduced long ago into the United States (California, Florida) for experimental purposes. India and Sri Lanka are the origins of the wood apple. It grows in a variety of tropical and subtropical climates, including India, Pakistan, Sri Lanka, and Southeast Asia. It is an extremelyhardy tree that may be found throughout India's plains in the northern, central, eastern, and southern areas, particularly in the semi-arid and arid regions of Maharashtra and Madhya Pradesh.

Common Names: English: curd fruit, elephant apple, indian wood-apple, monkey fruit, wood apple; Hindi: Bael, Bengali: Bael, Arabic: Safarjale, Marathi: Belaache zaad, Tamil: Vilvamaran, Malayalam: Koolam, Gujarati: Billu, Kannada: Belladi Hannu, Marathi: Bel

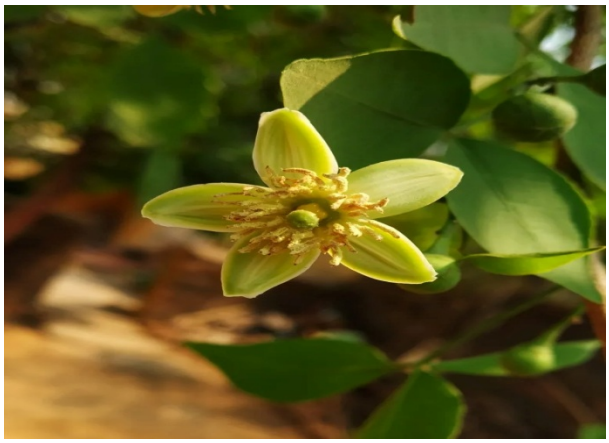
Scientific classification

Kingdom:Plantae
Clade:Tracheophytes
Clade:Angiosperms
Clade:Eudicots
Clade:Rosids
Order:Sapindales
Family:Rutaceae
Subfamily:Aurantioideae
Genus:Limonia
Species: acidissima
Binomial name: *Limonia acidissima* L.

Botanical Description

Botany of wood apple: Stamens are 7-12 in number, filaments is very shorts while anther is very large; disc is finely wooly; ovary with numerous ovules in each cell, style is very short and stigma is fusiform. It is a tree of 10-15m height and 0.8- 1.6m girth with deciduous nature having numerous branches. Leaflets opposite in 2-3 pairs and usually with a terminal one nearly sessile 2.5-3.8cm long . It is a monotypic species belongs to the family Rutaceae.

Flowers are dull red usually unisexual, male and bisexual flowers are seen on the same inflorescence. Peduncle is slender and pubescent .Calyx is very small; petals ovate, acute, spreading and smooth. Staminate and perfect flowers, 5-merous, white, green or reddish-purplish, usually together in lax, terminal or axillary inflorescences. The panicles occur generally on new shoots. The flowers can also be a mixture of staminate and hermaphrodite.



Flower of wood apple

The fruits obtained from the plants are edible and the pulp of the fruit is acid-sweet with coarse texture seediness and fibrous. The fruit is round to oval, 2 to 5 in (5-12.5 cm) wide, with a hard, woody, grayish-white, scurfy rind about 1/4 in (6 mm) thick. The pulp is brown, mealy, odorous, resinous, astringent, acid or sweetish, with numerous small, white seeds scattered through it. Seeds 0.2-0.24 in. (5-6 mm) long, hairy, with thick, green cotyledons; germination epigeal. In Malaya, the leaves are shed in January, flowering occurs in February and March, and the fruit matures in October and November. In India, the fruit ripens from early October through March.

Fruit of wood apple

Wood apple, *Feronia limonia* (L.) Swingle (Rutaceae), is a monotypic genus with two forms: one has large, sweet fruit and the other small, acid fruit. The species is native and common in southern India and Sri Lanka. It is also frequently grown throughout South-east Asia, in northern Malaysia and on Penang Island. In India, the fruit was traditionally a ‘poor man’s food’ until processing techniques were developed in the mid-1950s.

Leaves: Leaves up to 4.7 in. (12 cm) long, imparipinnate with narrowly winged rachis and petiole; leaflets opposite in 2-3 pairs and a terminal one, obovate, up to 1.6 in. (4 cm) long, dotted with oil glands and faintly aromatic when crushed.

Difference between Woodapple and Stone Apple: Wood apples and stone apples are alternative names for the same fruit, scientifically known as Aegle marmelos. Both terms refer to the fruit of this tree, which is characterized by its hard, woody exterior.

Here's a more detailed comparison:

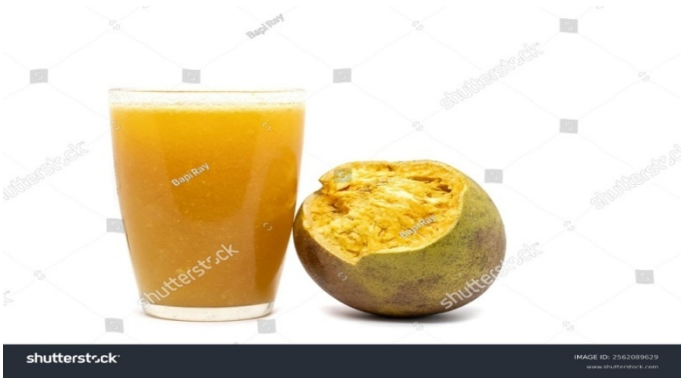
Wood Apple:

- Description: A hard-shelled fruit that needs to be broken open to access the pulp and seeds.
- Flavor: Sweet, aromatic, and slightly tangy, sometimes described as marmalade-like.
- Uses: Culinary (made into jams, squash, smoothies), medicinal (traditionally used for digestive issues), and cultural (used in religious ceremonies).
- Other Names: Bael, Bilva, Bengal Quince.
- Nutritional Value: Rich in vitamins (C, riboflavin, B vitamins), minerals (calcium, potassium), fiber, and antioxidants.

Stone Apple:

- Description: Refers to the fruit's hard, stony exterior, similar to the wood apple's.
- Flavor: Same as wood apple (sweet, aromatic, and tangy).
- Uses: Same as wood apple (culinary, medicinal, cultural).
- Other Names: Bael, Bilva, Wood Apple.
- Nutritional Value: Same as wood apple (rich in vitamins, minerals, fiber, and antioxidants).

In essence, "wood apple" and "stone apple" are interchangeable terms for the same fruit, Aegle marmelos, emphasizing its hard, woody shell.



Wood apple sharbat

Uses of Woodapple

Fruit; medicinal; cosmetics; ornamental: The hard rind of the ripe fruit must be cracked open with a hammer and the pulp scooped out. The pulp is eaten raw with or without sugar, or is blended with coconut milk and palm-sugar syrup. In Indonesia, the pulp is beaten with pal suagra and eaten at breakfast. The pulp can also be processed and drunk as a beverage or sherbet, or frozen as an ice cream. Ripe fruit juice is a good health drink and provides a rich source of anti-oxidants. The pulp is also made into chutney, preserves, jelly, marmalade, jams or processed into treacle or toffee. In Sri Lanka, wood apple cream is processed from the fruit pulp and is canned and exported. Young leaves, tender shoots and ripe fruits are also eaten fresh in Thailand. The jelly is purple and much like that made from black currants. A bottled nectar is made by diluting the pulp with water, passing through a pulper to remove seeds and fiber, further diluting, straining, and pasteurizing. A clear juice for blending with other fruit juices, has been obtained by clarifying the nectar with Pectinol R-10. Pulp sweetened with sirup of cane or palm sugar, has been canned and sterilized. The pulp can be freeze-dried for future use but it has not been satisfactorily dried by other methods. In the city of Rembang in Central Java, Buah Kawista is famously processed into a sticky, brown syrup known as Kawis syrup. Rembang's climate is well-suited for Buah Kawista, and the majority of the Kawista trees are planted in the home gardens of Rembang residents. 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. Many Indonesians travel to Rembang solely to purchase the dark brown syrup, and there are multiple producers, with the most famous being Cap Dewa Burung. Buah Kawista contributes a complex blend of sugary, sweet, and sour flavors, and the syrup is often likened to the taste of carbonated colas. Kawista syrup is primarily served over ice and is nicknamed the Javanese cola.

Medicinal properties: The tree is one of the most useful medicinal plants in India. The powdered gum, mixed with honey, is given to overcome dysentery and diarrhoea in children. The fruit is used in India as a liver and cardiac tonic. Unripe fruit are used as a means of halting diarrhoea and dysentery and as an effective treatment for hiccough, sore throat and gum diseases. The pulp is poulticed onto bites and stings of venomous insects, as is the powdered rind. Juice of young leaves is mixed with milk and sugar candy and given as a remedy for biliousness and intestinal troubles of children. Leaf oil is applied to alleviate itching and the leaf decoction is given to children as an aid to digestion. The spines and bark are crushed and an infusion taken as a remedy for excess menstruation, liver disorders, bites and stings.

Medicinal Property

- It is recommended as a remedy for chronic dysentery.
- The fruit especially used as a liver and cardiac tonic
- Unripe fruit is an effective treatment for hiccups, cough, sore throat and disease of the gums
- The trunk and branches of wood apple trees contain a gum-like substance called "Feronia gum". It is mostly used in curing diarrhea and dysentery.
- It is also recommended for people with peptic ulcer or piles since wood apple tree leaves contain tannin, which is known to reduce inflammation.
- The laxative property of wood apple also helps to avoid constipation and the subsequent, pain, discomfort and associated health risks of that condition.
- These attributes combined with the antifungal and antiphrastic activities make this fruit ideal for enhancing the digestive health.
- It has curative value for various diseases of bones and joints, bilious diseases, controlling of capillary bleeding, cold, influenza, piles, dysentery, habitual constipation and scurvy.
- Juice of young leaves is given as a remedy for biliousness and intestinal troubles of children.
- Oil derived from the crushed leaves is applied on itch and the leaf decoction is given to children as an aid to digestion.
- Leaves, barks, roots and fruit pulp are all used against snakebite.

Health benefits of wood apple

1. ***Prevents stomach illnesses:*** Wood apple, also known as bel, contains antidiarrheal qualities that can prevent stomach illnesses and diarrhoea brought on by the germs E. Coli and Shigella. The bel tree's unripe fruit helps prevent the growth of harmful bacteria in the digestive tract. Wood apple has been used to treat diarrhoea for ages, first in Ayurveda and then in folk medicine.
2. ***Defend against germs:*** Wood apple has chemicals that can defend against germs that cause disease, including fungi, viruses,

and bacteria. Bacillus subtilis, Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa are the microorganisms that it is most effective against. Coxsackievirus, which causes diseases like meningitis, hemorrhagic conjunctivitis, myocarditis, and encephalitis, has also been proven to be susceptible to its antiviral effects.

3. ***Anti-cancer:*** Bel's radio protective chemicals shield healthy tissues from radiation's free radical damage, which can lead to cancer.
4. ***Treats fever:*** The antipyretic properties of wood apple help reduce fever. After administering fruit extracts to animals, researchers discovered that the fevers of the test subjects decreased after taking the supplements.
5. ***Good for kidneys:*** Wood apple is diuretic, thus it aids the kidneys in flushing out excess sodium via the kidneys and out of the body. This has positive effects on blood pressure and kidney function. It reduces blood pressure by easing tension in the veins and arteries.

Nutritional value of wood apple:

Carbohydrates: 31.8 mg
Fat: 0.3 mg
Vitamin C: 60 mg
Proteins: 1.8 mg
Vitamin A: 55 mg
Fibre: 2.9 mg
Calcium: 85 mg
Potassium: 600 mg
Energy: 137 kCal
Minerals: 1.79gm

Taste: Wood apples are small to medium in size, averaging 5 to 12 centimeters in diameter, and are round to oval in shape, fitting into the hand like a small coconut. The fruits showcase a hard, woody, speckled, grey-brown to light brown exterior shell, and the surface is rough and textured. The tough, fibrous shell must be cracked open using a rock, hammer, or back of the knife, and once opened, a solid, dense flesh envelops the shell. The flesh ranges in color from ivory to yellow when young, transitioning into an orange-brown or dark brown hue with age. The flesh has an unusual blend of textures due to long, stringy fibers and seeds, creating a sticky, grainy, soft, jammy, mealy, moist, and subtly crunchy consistency. It is important to note that the seeds and fibers are edible and do not need to be removed. It is nearly impossible to determine the ripeness of Wood apples just by appearance alone. To test for maturity, the fruit is traditionally dropped on the ground from a height of about 30 centimeters, and if the fruit bounces, it is not ripe. If the fruit drops and lands with a soft thud without bouncing, it is considered ready to eat. Once ripe, Wood apples release a pungent, permeating, and polarizing aroma. Some consumers liken the scent to a blend of blue cheese and raisins, while others say it smells like an overripe banana mixed with rotten blue cheese. The raw flesh also has an unusual flavor enjoyed by some consumers and despised by others, all dependent on personal preferences and taste. Ripe Wood apple flesh has a sweet, astringent, acidic, and sour flavor with musky, fermented, and tangy nuances reminiscent of tamarind, raisins, and sharp cheeses.

Cultivation procedures

Climatic and soil requirements: Wood apple can be grown in dry tracts of tropical and sub-tropical regions right from sea level, upto 1400 m above MSL. It is adapted to a wide range of soil conditions including degraded soil. It can also tolerate salinity to certain extent. It is an ideal tree to be exploited for growing in wasteland. Sandy loam or deep loam with a pH of 7-7.5 and well-drained soils are required for excellent yield potential and good plant growth. It can adapt to a wide range of ecological circumstances, owing to its extensive geographical distribution, which ranges from tropical and subtropical to arid and semi-arid environments. It is an excellent fruit tree for semi-arid and desert environments. It is highly suitable fruit tree for semi-arid and arid ecosystem.

Varieties: Budded plants are seen to be dwarf, precocious and prolific bearer. Vegetative propagation by grafting and budding is possible in wood apple. Rainy reason is found to be the most favorable time for vegetative propagation. Wood-apple is generally propagated by seed. HB-10 released from Marthawada Agriculture University (MAU), Parbhani, Maharashtra having average weight of fruit 350g with weight of pulp 224g. Propagation no named or standard cultivars of this fruit. There are 2 forms, one with large, sweetish fruits; one with small, acid fruits.

Propagation: The wood-apple is generally grown from seeds though seedlings will not bear fruit until at least 15 years old. Seeds germinate after 2-3 weeks in the nursery; 80% germination may be achieved for seed stored for several weeks. Buds from mature wood grafted onto seedlings are said to result in dwarf trees which fruit early. Vegetatively propagated trees flower in 3 years. During the months of March and April, it is commercially propagated by seed, soft wood grafting, orpatch budding in both field and nursery conditions. In situ soft wood grafting yields more than 80%success in wood apple in Gujarat's semi-arid climate. Propagation is done mainly by seed propagation and budding. Budded plants are dwarf and precocious in bearing.

***Field preparation and planting*:** The spacing of 8mx8m each pit with a size of 1 m x 1m x 1m is ideal. Planting should be done at the onset of monsoon after filling the pit with 20 kg FYM, sand and top soil. The basins should be formed immediately after planting in such a way that water harvesting is facilitated.

Intercultural Operations Training is done by Central leader method allowing well spaced branches in all directions. For the additional benefits, intercrops can be taken during rainy seasons for the first 5 years. In the post monsoon season, the basins can be mulched with dry leaves. Every year 25 kg of FYM is to be applied for each tree at the beginning of the monsoon rains. This will help in increasing fruit-size, taste and quality. During early stages of crop growth, if pot watering is done during summer it will be beneficial.

Flowering, pollination and The fresh pollen grains are dark yellow. Both perfect and staminate flowers have 10-12 stamens of equal size. The anthers are basifixed dehiscing through a slit between the two pollen sacs of each lobe. The flowers are mainly staminate and hermaphrodite. Ovary, style and stigma are present in both hermaphrodite and staminate flower, but rudimentary in the later. Opening of the flowers start in the 2nd week of March. Emerges of panicles commences in the middle of February and continue upto 3rd week of May. Small flowers are borne on terminal or axillary panicle, mainly on new shoots. The crop is highly cross-pollinated by insects.

Training and pruning: For appropriate frame work, initial to three-year training and pruning is mainly required. Although the wood apple does not require pruning, it is necessary to remove dry, dead, and cross branches during the months of December and January. Plant protection There are no major insects and diseases have reported in wood apple. Nevertheless, conservation of run off rain water in root zone will enhance the productivity of this crop. Irrigation for a few weeks at beginning during planting is essential. Wood apple is normally a crop of dry region and once the plant are established, they hardly need any irrigation. Irrigation:- ¬pruning:- Trees are allowed to grow freely on central leader with well-spaced branches in all directions.

Manuring*:* Clean cultivation by weeding around the root zone and ploughing the entire orchard after rainy season or during autumn will minimize weed completion and conserve moisture. If manured at the rate of about 25kg FYM or compost per tree in the beginning of the monsoon. It will help in increasing fruit size and quality. No manuring schedule is followed for wood apple cultivation and there is no any experimental report to adopt to apply fertilizer. In full-grown trees, an annual dose of around 50 kg FYM, 1.5 kg N, 500g P, and 500g K_20 per plant per year should be applied in full grown tree and it

should be applied each year in two splits during July and last week of August.

Irrigation management: Plants should be irrigated during the summer at a young age (up to two years) to ensure appropriate growth and establishment. Although wood apple can be grown in a rainfed semi-arid environment without irrigation, planting should be done as soon as rain begins to ensure that the plant establishes through out the rainy season.

Pest Control Being a member of citrus family it is attacked by the leaf-eating caterpillar of citrus which completely defoliate the plant. Spraying of any contact insecticide should be done after hand picking and destruction of larvae.

Harvest and yield: 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 a 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.

CONCLUSION

Poor diet can be said an invitation to multiple diseases. Fruit diet can prevent those diseases. By this we can prove what Hippocrates said, “Let food be thy medicine and medicine be thy food”. Not only in fresh form but the underutilized fruit can also be utilized in dehydrated forms for making their availability year round to be taken by common people. Fruits provide all the essential nutrients such as vitamins and minerals. The value added products of the fruit need surge to catch the national and international markets if it is properly focused under nutritional care of inputs along with plant protection measures. The present overview on this fruit crop is mainly emphasis on nutritional, food and medicinal value and its impact on betterment of human health wellness through intake of vitamins, minerals, total sugars and ascorbic acid content. In spite of their high nutritional and medicinal values, their commercial cultivation is lacking and needs to be popularized for commercial acceptance and orchard establishment under arid and semi-arid zones to attain sustainability in fruit production. Wood apple, or bael, is a remarkable fruit packed with health benefits and versatile uses. From boosting digestion and immunity to supporting heart health and managing diabetes, its nutrient-rich profile makes it a powerhouse of wellness. Whether consumed as juice, pulp, or in traditional remedies, every part of this fruit offers something valuable. Its unique flavor and countless medicinal properties make it a must-include in your diet, especially during the summer. Wood apples have a complex sweet, sour, musky, and fermented flavor suited for fresh preparations. Embrace this super food to enjoy its natural goodness and enhance your overall health.

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