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Research Article

Phytochemical Properties and Health Benefits of *Limonia acidissima*: A Review

Pooja Sharma^{1*}, and RK Tenguria²

¹Department of Biotechnology and Bioinformatics Center, Barkatullah University, Bhopal-462026, M.P. India

²Division of Microbiology, Department of Botany, Govt. Motilal Vigyan Mahavidyalaya, Bhopal-462008, Madhya Pradesh, India

Correspondence email: ps802715@gmail.com

Abstract

In today's generation herbs are playing a significantly role in every industry due to their various properties. India is such a prosperous origin of many useful medicinal plants. These plants acquire the possibility to treat diversified human diseases and ailments. Plants along with medicinal properties have been recognized by people as long as thousands of years. Ayurveda is one of the most prehistoric setup in the worldwide for medicine, which contribution leads for enormous number of therapeutically favorable compounds. *Limonia acidissima* is one of the best eye catching Plant along with various medicinal and nutraceutical characteristic. *Limonia acidissima* Linn (*Feronia elephantum*, *Hesperethusa crenulata*, *Feronia limonia*, *Schinus limonia*) belongs from family Rutaceae (Citrus) and monotypic genus Limonia. Commonly *Limonia acidissima* contain various name such as monkey fruit, wood apple, curd fruit, elephant apple, kaitha and kavit in India. Native to India as well as it has planted in Pakistan, Bangladesh and Sri Lanka. The Leaves, bark, roots and fruits are extensively used in medicine and also commonly used for the treatment of chronic diarrhea, dysentery, and peptic ulcers, and it is also treat myriad ailments. Currently, broadly scientific studies have been corroborated for its ethnomedicinal properties and assortment of bioactive compounds in distinct parts of wood apple tree. The present article is mainly considered for the morphology, nutritional value, phytochemistry and pharmacological actions of the different parts of *Limonia acidissima*, these has been widely underutilized and slighted.

Keywords: *Limonia acidissima*, pharmacological action, rutaceae, phytochemistry, nutraceutical properties.

INTRODUCTION

Plants have been considered with medicinal properties from thousands of years, for the medication of diseases it has been used by the people to treat diseases. Botanically developed medicines have been played a large scale role in the human society from the history and prehistory. In the medicinal science sometimes chemically synthesized drugs shows many side effects on the body and their high cost, therefore the traditional medicines are being beneficial for all over the world (Lewis & Lewis, 2003). The taxonomical classification *Limonia acidissima* shown in Table 1. In primitive time, human recognize their medicinal properties of plants through their personal experimentation however, they were not figure out the scientific deliberate and performance of their medicine. Nowadays we are in very improved situation to know the anatomy and multifunctional chemical power for the medication of acute and chronic disease. In non-industrialized community, medicinal plants

are broadly used because they have insignificant side effects as compared to modernized medicine because these medicines are cost effective and cheerfully available for all communities (Malviya et al., 2012). India is recognized as "Botanical garden" it having 7500 medicinal plants into the 17000 taller plant species (Shiva, 1996).

Limonia acidissima L. (syns. *Feronia limonia*; *Schinus limonia* L; *F. elephantum*) is a moderate-sized tree which belongs to family Rutaceae and monotypic genus Limonia (Figure 1 a, b and c). It contain various names in different regions such as english name is wood apple, and also called curd fruit, monkey fruit, elephant, kaitha in hindi and other names in India. Wood apple is one of the most eye catching plant with various medicinal and nutraceutical properties (Morton, 1987). Different segment of the tree such as barks, leaves and fruits have been used for many ailments and diseases in traditional medicine (Qureshi et al., 2010). Recently, broadly scientific investigations have

Table 1. Taxonomical classification: (Panda et al., 2013).

Kingdom	Plantae
Sub-kingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Division
Class	Magnoliospida
Subclass	Rosidae
Order	Sapindales
Family	Rutaceae
Genus	Limonia L.
Species	L. acidissima.

**Figure 1.** *Limonia acidissima*: Tree [a] Fruit pulp [B] Leaves [C].

corroborated for ethno-medicinal properties along with a collection of bioactive compounds in distinctive parts of wood apple. The leaves, bark, fruits and roots are largely handled in Ayurvedic medicines along with dysentery, peptic ulcers, chronic diarrhea and myriad ailments are also treated by the use of wood apple. Despite the fact fruit of *Limonia acidissima* are mostly useful for preparing food products such as puddings, murabba and fresh juice (Srivastava et al., 2019). Leaves contain psoralen, stigmasterol, orientin, vitedin, bergapten, tannins, saponarin and some essential oils (Chatterjee et al., 1980). According to Saima et al, the fruit accommodate of flavanoids, glycosides, saponins and tannins (Saima et al., 2000) and few coumarins. Fruit shells consist of antifungal compounds specifically. Osthenol, Psoralene, xanthotoxin, 2,6 dimethoxybenzoquinone (Adikaram et al., 2007) The vernacular names of wood apple shown in Table 2.

Futhermore tyramine derivatives have been also isolated to the fruit of *Limonia* (Ghosh et al., 1991). The stem bark of the plant has provide (-)-(2S)-5,3'-dihydroxy-4'-mrthoxy-6'',6''dimethyl chromeno- (7,8,2'',3'')-flavanone and also different well known compounds, it contains an alkaloid, five coumarins, a lignin, a flavanone a triterpene, and three sterols, which were establish to acquire antimicrobial activity (Rahman and Gray., 2001). The gum is peacemaking, festering and it is convenient in diarrhea, gastropathy, dysentery, diabetes and haemorrhoids (Nadkarni, 1996). Inadequate studies have been reported on pharmacological and therapeutic actions of wood apple. The study purpose of current review is to record the medicinal and nutritional values of wood apple for stimulate the utilization and application of this medicinal plant as a promising source for drugs throughout the nature.

Origin and geographic distribution

Native to India, as well as this is planted in Pakistan, Sri Lanka, Bangladesh (Bhandari, 1978; Bakshi et al., 2001). This is cultivated generally in central dry forest and southern of India. It is found in jungle and also usually grown as a border plant (Khare, 2007).

Ecology

The wood apple prefer a seasonally or monsoon weather along with a specific dry season for the growth. It is indigenous tree and naturally grown in dry plains and Ceylon. This is ostensibly drought permissive and most excellently adapted to light soil. It is grown up to 0- 450 m altitude in the Western Himalayas (Vaidyaratnam & Kottakkal, 1995). The plant grown in a various diversity of soils but excellent harvest has achieved in a well dried and sandy loamy soil, which has acidic or contain neutral pH. This soil has maintained the suitable condition for plant growth. The purpose for proper growth of *limonia acidissima* has planned to block water stagnation for annually and to develop the proper quality, fruit shape and size. The tree is impressionable for water erosion from dry land and temperature 20-29°C is required for the proper growth of *Limonia acidissima* (the earth of India, 2013). In India a fruit of plant obtain the full growth in month of October to November, the starting of October to end of the March, fruit of the *limonia acidisima* grown and ripens completely. In Malaysia and other countries the leaves sheds in month of January but in India leaves sheds in month of February. Flowering appears in February to March. Sooty moulds, which is generally infect the tree, this infection can be obviated by spraying the mixture of Methyl parathion and also gum acacia (Reddy, 2016).

Table 2. Vernacular names of wood apple (Guha et al., 1999).

S. No.	Language	Names
1	English	Wood Apple, Elephant Apple, Curd fruit, Monkey fruit
2	Hindi	Kaitha, Kath Bel or Kabeet
3	Oriya	Kaitha
4	Sanskrit	Kapittha or Dadhistha.
5	Telgu	Vellaga Pandu
6	Bengali	Koth Bel
7	Gujarati	Kothu
8	Malaysia	Belingai
9	Malayalam	Vilam Kai

Botanical characterization

Limonia acidissima L. is a moderate sized, deciduous, erect tree along with a certain higher reaching branches arching outward nearby the crowning point where they are separate in to slender and branchlets enervated in the direction of tips throughout India (Kumar and Deen, 2017). This is a very slow growing tree up to 9 meters tall. Generally it is polygamomonoecious tree and growing with rough and spiny bark. Spines of the tree are short, auxiliary, straight, few of zigzag twigs and 2-5 cm long (Smith, 1985). Leaves of the tree are pinnate along with 5-7 leaflets and every leaflet is 25 to 35mm elongate and 10-20mm thick, it gives lemon type scented when it is oppressed. Taste of the fruit is sometime may be sweet and sometime may be it is sour. Fruit has an enough unmerciful rind, which cannot be easily to break by hand and internally it holds sticky brown colour pulp along with pint size white color seed (Ghosh et al., 1982).

The leaves of the tree have been dark green, deciduous, and intersperse, leathery and 3 to 5 inches long. Generally pointed irregular, blunt, roughs at the apex, spotted along with oil glands. Flowers are red or greenish, narrow numerous dull, naturally innate in small size, unconstrained, lethal or oblique panicles (Bhandari, 1978). Fruit shape is round to oval, berry, spherical, 2 to 5 inches roomy along with the tough, wooded rind. The rind is around 6mm thick and which is grayish-white. Pulp of the fruit is astringent, sticky brownish, it contain aromatic fragrance, adhesive, acidic or sweetish, seeds of fruit are white, which is dispersed throughout it. Two forms of the fruit are available, one is small which is acidic and other is large form which is sweet in taste (Chopra et al., 1956; Vaidyaratnam & Kottakkal, 1995).

Nutritional report

The fruit of *limonia acidissima* were figure out by the investigator for imminent, vitamins, minerals, and nutrients, in which present (per 100g) nutritional material. Researcher has been figure out the 64.63g moisture in wood apple along with 1.38g of fat, it consist 6.78g of protein, and 5.00g of crude fibre, 20.66g of carbohydrates has present, 1.55g of ass with 122 Kcal of energy. According to investigator, minerals were identify in wood apple, such minerals are 122mg of calcium, 110mg of phosphorous, 0.38mg of iron,

0.50mg of zinc, 0.25mg of copper, 37.85mg of manganese, 0.05mg of sodium and 2.64mg of potassium, commonly. 5.00mg of vitamin c per 100 G were found (Anita, 2015). Such minerals are involve to regulating the metabolic activities in human body, high level of phosphorous involve in the formation of bones and also further necessary metabolic activities. Calcium involve in the neuromuscular operations apart from this, it is play a demanding role for producing harshness to the skeleton, blood clotting, along with another metabolic activities (Campos et al., 2009). Wood apple consist of iron, which is the play a valuable role against tuberculosis, disorders of growth and anemia. For diabetes mellitus, the zinc supplements demonstrates for its having antioxidant effects (Roussel et al., 2003). For maintain of ionic balance and tissue excitability in the human body, where as sodium and potassium involves in these activities. Potassium required for its diuretic character besides sodium takes a part in the transport of metabolites. The highest ratio of potassium and sodium in any food, both are play important role in avoidance of arteriosclerosis and hypertension. Sodium increases and potassium reduces the blood pressure (Saupi et al., 2009). The acidic heteropolysaccharide has been segregated out of possession of the tropical angiosperm *limonia acidissima* (Saima et al., 2000).

For the formation of zinc oxide nanoparticle, the scientist has identified the aqueous extract of leaves of *Limonia acidissima*. These zinc oxide nanoparticals regulate the development of *M. tuberculosis* situated at 12.5µg/mL (Bheemanagouda & Taranath., 2016). The fruit of *Limonia acidissima* is used for preparation of food product and also it is edible, recently investigators occupied the anti-hyperlipidaemic and anti-hyperglycaemic actions of fruit along with used in folk medicine, for the treatment of various ailments. In view of phytosterols, saponins, flavonoids, polyphenols, fibers and total ascorbic acid are recognized as impact of both lipid and carbohydrate metabolisms, expenditure of *Limonia acidissima* fruit pulp is favorable in regulating the hyperglycaemia and hyperlipidaemia in fluoride –induced toxicity (Vasant and Narasimhacharya., 2013). The occupancy of vitamins in fruit pulp such as vitamin B1 and B2 perhaps help to change carbohydrates in to energy, it is also important for growth, healthy skin, eyes and construction of red blood cells. Other than this the beta carotene (it is a harbinger of vitamin A) as well as it involves

in care of teeth, mucous membranes and bones (Pandey et al., 2014) showed in Table 3.

Medicinal properties

According to researcher, many plants and their plant derivative aggregates acquire extreme levels of antioxidant characteristics and also exposed wound healing actions through scavenging of these free radicals (Aggarwal & Sardana, 2013). The fruit pulp acquire free radical scavenging, antibacterial, antioxidant, anticancer, anti-ulcerative colitis, gastro-protective, antiviral, anti-diarrheal, hepatoprotective, prohibition of lipid peroxidation, antidiabetic, radioprotective effects, cardio protective and also includes extensively range of therapeutic effects [6]. In Yunani the fruit are used to treat blood impurities, urinary problems and leucorrhoea (Gupta et al., 2009). Seeds are used for figure out heart diseases although the unripe fruit is used as an astringent (Senthilkumar et al., 2010). The Pharmacological properties of wood apple showed in Table 4. Ripe fruits are used for the medication of tumours, asthma, wounds, cardiac debility and hepatitis as the same the bark and leaves of the tree are generally used for vitiated conditions of vata and pita (Kirtikar & Basu, 2005).

As a consequence the leaves of the plant were described to maintain hepatoprotective activity (Kamat et al., 2003). Studies have describe, when the oil of the leaves blended along with a pinch of black pepper, so this is used as a carminative (Shermin et al., 2012). Leaves are astringent and carminative, which is wonderful medicine for hiccup, vomiting, indigestions and dysentery (Iliango and Chitra, 2009).

Phytochemicals

The examination of primary phytochemicals in *Limonia acidissima* tree, demonstrated through the occupancy of flavonoids, alkaloids, terpenoids, phenols, fats steroids, tannins, glycosides, saponins, gum, mucilage, and settled oils (Panda et al., 2013; Jayashree & Londonkar, 2014; Vijayvargia et al., 2014; Thomas & Ponnammal, 2005). Leaves of the tree accommodate psoralen, stigmaterol, orientin. Bergapten, vitedin, saponarin, tannins, with some essential oils (Patra et al., 1988). According to Rahman et al Bark contain Marmesin, feronolide and also feronone (Rahman and Gray, 2002). Unripe fruits of the plant accommodate stigmaterol and pulp of fruit encompasses the enormous quantity of citric acid along with fruit acids,

Table 3. Nutritional reports of *limonia acidissima*.

S.No.	Nutrients/ Minerals & Vitamins	Joshi & Jain (2008)	Morton (1987)	Jyotsana et al., (2015)	Priyadarshini et al., (2013)
1	Moisture (%)	70.6	74.0	72.4	85.0
2	Protein (%)	7.5	8.0	7.2	3.19
3	Fat (%)	3.3	1.45	2.07	-
4	Carbohydrate (%)	22.1	7.45	15.13	42.2
5	Fiber (%)	-	-	-	11.52 crude
6	Ash (%)	4.6	5.0	3.2	8.5
7	Vitamin C (mg/100g)	15.9	-	66.4	-
8	Ascorbic acid (mg/100g)	-	-	-	-
9	Calcium (mg/100g)	-	-	88.8	-
10	Phosphorous (mg/100g)	-	-	98.8	-

Table 4. Pharmacological properties of wood apple.

S.NO.	Pharmacological Actions	Extract	Phytoconstituents	Plant Parts	References
1	Anti- tumour	Acetone extract, chloroform-ethanol	Acidic polysaccharide	Fruit, pulp	(Saima et al., 2000)
2	Anti- oxidant	Methanolic extract, Acetone extract, Aqueous extract	Essential oil	Fruit, Stem bark, Fruit pulp & leaves	(Kumar and Venkatesalu, 2013; Shermin et al., 2012; Nanasombat et al., 2012)
3	Anti- diabetic	Aqueous extract Methanolic extract	Flavonoids, Phenols	Fruit, stem bark	(Priya et al., 2012)
4	Cytotoxic	Methanolic extract		Stem bark	(Shermin et al., 2012)
5	Analgesic	Ethanolic extract	Tannins, Steroids, Flavanol, Alkaloids	Leaves	(Momin et al., 2013)
6	Anti-diarrhoeal	Ethanolic extract	Tannins, Flavonoids	Leaves	(Momin et al., 2013)
7	Anti-histaminic	Ethanolic extract	Polar constituents	Bark	(Chavan et al.,)
8	Anti-inflammatory	Ethanolic extract		Leaves	(Khare et al., 2014)
9	Anti-bacterial	Aqueous extract, Ethanolic extract	Essential oil	Leaves, fruit pulp	(Kumar et al., 2010)
10	Anti-microbial	Aqueous extract	Essential oil	Fruit pulp	(Kumar & Venkatesalu, 2013)

Table 5. Phytochemical analysis of wood apple 54.

S. No.	Phytochemicals	Fruit pulp	Leaf	Stem
1	Amino acids	-	+	+
2	Alkaloids	++	-	-
3	Carbohydrates	+++	-	+
4	Flavonoids	+++	+++	++
5	Tannins	+	+	-
6	Cardiac glycosides	++	+	+
7	Triterpenes	-	-	+
8	Steroids	+	+	-
9	Saponins	-	+	++

minerals and mucilage. In the pericarp, coumarins, fatty acids, sterols and alkaloids have been recognized with fruit is also contains scoparone, dictamnine, xanthotoxol, umbelliferone, xanthotoxin, isopimpinellin, isoimperatorin and also marmin (Chakroborty, 1959).

Root consists of feronia lactone, bargapten, geranylum belliferone, isopimpinellin, osthol, marmesin and marmin and seeds contain carbohydrates, proteins, fixed oil and amino acids (Patel et al., 1982). Pandavadra and chanda have given the results of qualitative phytochemical analysis of the crude powder of *Limonia acidissima* leaf and stem, both has confirmed the leaf had highest amount of tannins and flavonoids and at the same time stem had only flavonoids. Few amount of cardiac glycosides, tripenes along with steroids were present in leaf and stem, saponins absolutely absent in leaf and stem (Pandavadra & Chanda, 2014). The phytochemical analysis of wood apple shown in Table 5.

CONCLUSION

Now we are in better condition to known understand how the body take actions, and recognize the healing functions of plants for treatments of convoluted health conditions. Medicinal plant consist mixtures of various chemical compounds which may perform action as individually and additively to become better health. *Limonia acidissima* is a traditional plant, it contain versatile medicinal properties which is known as a system of traditional medicine. It carried pharmacological characteristic such as anti-diabetic, anti- cancerous, anti-diuretic, anti-inflammatory and anti histaminic. It is maintain a good nutritional value that is beneficial for the body and also it consist the phytochemical compounds such as phenolic compound, tannins and flavonoids, which are act as anti-oxidant, anti-fungal and anti-bacterial, Anti-inflammatory compounds that reduces swelling and pain. The cultivation of wood apple by farmers is beneficial for the purpose of business and also profitable for pharmacologist if they want to work on the plant

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