Original Article
IASR Journal of Medical and Pharmaceutical Science
Website: https://ijmps.com/
ISSN (online): 2582-9343
Page No : 60-68

Medicinal Uses and Pharmacological Activity Wood Apple (*Limonia Acidissima*) : A Review

Navneet Kumar Verma[*1], Asheesh Kumar Singh[2], Ram Kishor[3]

[1]Associate Professor, Buddha Institute of Pharmacy, GIDA, Gorakhpur Affiliated to Dr. APJ Abdul Kalam Technical University, Lucknow, UP, India
[2]Professor, Buddha Institute of Pharmacy, GIDA, Gorakhpur Affiliated to Dr. APJ Abdul Kalam Technical University, Lucknow, UP, India
[3]Students, Buddha Institute of Pharmacy, GIDA, Gorakhpur Affiliated to Dr. APJ Abdul Kalam Technical University, Lucknow, UP, India

ABSTRACT

A fruit of the Rutaceae family with less commercial use is the wood apple. Food preparations all throughout the world use the fruit pulp, which is edible. It has also been used for centuries as a traditional medicine. Although they are not frequently used, seeds from fruits like Citrullus (C.) lanatus (watermelon) and Limonia (L.) acidissima (wood apple) could be useful in many food formulations. It was determined that defatted seed flours had protein contents of 71.38 and 49.51 percent, respectively, and that they also included significant amounts of minerals like Na, Mn, Mg, K, Cu, Fe, and Zn. the reduced L. The goal of this review was to provide an overview of the fruit's pharmacological potential. This fruit is useful against a number of dangerous diseases, including bacterial infections, cancer, diabetes, and hyperlipidemia. pH, total soluble solids, titratable acidity, ascorbic acid, and biochemical characteristics (total phenolic content and antioxidant activity) of the chutney were examined during the storage period. One of the native milk products is kalakand, which is made by heating whole or standardised milk and then concentrating it with the addition of sugar and the right coagulant. The goal of the current experiment was to create Kalakand by incorporating wood apple pulp into it at various concentrations while using buffalo milk. Additionally, it has the ability to treat pain, ulcers, and diarrhoea. Fruit's pharmacological action is significant in both ripe and unripe forms. The principal antioxidant responsible for the medicinal potentials is flavonoids and phenolic compounds.

Keywords: *Wood Apple; Limonia Acidissima*

Corresponding Author
Navneet Kumar Verma
Associate Professor, Buddha Institute of Pharmacy, GIDA, Gorakhpur Affiliated to Dr. APJ Abdul Kalam Technical University, Lucknow, UP, India

INTRODUCTION

Wood apple (*Limoniaacidissima)* Fruit is a commonly found member of the Rutaceae family and is an underappreciated fruit. Elephant apple, monkey apple, Kotha, kainth, and other names are also used to refer to it in different regions of India. It is typically found throughout the plains in states like Maharashtra, West Bengal, Chhattisgarh, Uttar Pradesh, and Madhya Pradesh. It is also found in the western Himalayas. [1, 3]The fruit's brown, extremely hard outer shell contrasts with the pulp's sour flavour and imbedded seeds. The amount of flavonoids, glycosides, saponins, and tannins in wood apples is sufficient. [4, 5]furthermore a rich source of ascorbic acid, riboflavin, vitamin B complex, beta-carotene, and minerals, with seeds having a high oil content [6].The fresh wood apple has 7.1 grammas of protein, 18.1 grammas of carbohydrates, 10.45-21.70 percent TSS, 1.98- 3.80 percent treatable acidity, 4.77-5.71 TSS/acid ratio, 0.30-6.03 percent reducing sugars, 5.65-13.80 percent non-reducing sugars, 7.95-19.83 percent total sugars, 3.86-6.82 mg/100g ascorbic acid, 221.50- 80.10 mg/100g total phenol, and 9.88 [7,9].Although having beneficial nutritional and medicinal qualities as well as a delicate flavour, this fruit is currently neglected. Dysentery and other infections are treated with wood apple in traditional medicine. Fruit contains photochemical that have hepatoprotective, antifungal, hypoglycemic, and anti-oxidative characteristics, as well as hypolipidemic and hypoglycemia effects. [11, 12]Different parts of wood apple plant have been reported to exhilarated liver tissue, cut injuries, skin malignant growth, bosom disease and cell reinforcement exercises [13]Wood apple fruit, which ripens to become soft, is used to make fruit bars, drinks, sweets, and fruit smash, which is used to make jam and ready-to-serve beverages. Fruit pulp is a useful ingredient in blended drinks made with coconut milk and palm sugar syrup. This fruit is still underutilized, not in demand, and has no market value in spite of its various nutritional and health benefits. As a result, an effort was made to

turn the fruit of the wood apple tree into a value-added product and to research its various physicochemical characteristics. [14, 15]According to the Rome IV Criteria, the sixth most frequently reported gastrointestinal (GI) disease is constipation, which is defined as the inability to pass less than 35 g of stools per day, less than 3 bowel movements in 7 days, a faecal water weight of less than 70%, and a gastrointestinal (GI) transit time of more than 5 days. [16, 17, 18]This will not only create new opportunities for maximising the use of nutritious fruits with large yields, but it will also encourage the growth of the wood apple processing business. Since consumers have the final say in what food is chosen, research on acceptability and nutrients is crucial. [19]It grows naturally in the dry plains of India, Pakistan, and Sri Lanka where it is also occasionally grown in orchards, along roads, and on the edges of fields. Additionally, it is grown all over Southeast Asia, particularly in Malaysia. The fruit was traditionally considered a "poor man's food" in India until processing methods were created in the middle of the 1950s. In addition to being known as "Wood apple," other names for it include "elephant apple," "monkey fruit," "curd apple," "Kethbel," "golden apple," "stone apple," etc. It is referred to as gelinggai or belinggai in Malaysia, ma-khwit in Thailand, kramsang in Cambodia, and ma-fit in Laos. It is known as pommel' elephant, pommel de bois, or citrondesmois in French. This well-known fruit contains a number of well-known and one of the most valuable medicinal plants in India due to its medicinal characteristics. The conversion of complex sugar into simple sugar during the wood apple product's storage period raises the product's overall solid soluble content. The data shows that the pH of the chutney dramatically reduced during the course of the storage time as a result of the wood apple chutney's increased acidity. The outcome Husaini et al. reported. [20] This level of acidity in mango chutney denotes pH fall brought on by increases in acidic ingredient over extended storage. Ascorbic acid was measured at 4.2 mg per 100 grammes on week zero and 2.2 mg per 100 grammes on the last week of storage. It was consistently reduced throughout the storage period as a result of ascorbic acid reacting with trapped oxygen in the glass bottle to produce highly volatile and unstable dehydrate ascorbic acid, which then degraded to ketogulconic acid or furfural compounds as a result [21,23]. Have been observed that ascorbic acid levels in squash made from wood apple fruit have gradually decreased. On the first day of storage, ascorbic acid levels in preserved wood apple reached 0.44 mg/100g.The amount of total phenolics in wood apple chutney dramatically declined during the course of storage; on the first day, it was 190.2 mg GAE/g, and by the last day, it had dropped to 143.7 mg GAE/g. According to Deng et al. [24], over the time that the litchi pericarp was stored, the phenolic content decreased gradually at first, but subsequently rapidly as a result of greater enzyme activity in the pericarp, which hastened the oxidation process. Furthermore, Joshi et al. [25]In India, fruit is frequently used as a liver and heart tonic. It is used to treat diarrhea and dysentery when it is unripe. In addition, wood apple exhibits hypoglycemic, anti-hyperlipidemia, wound-healing, anticancer, diuretic, larvicidal, and antimicrobial activity, as well as hepatoprotective, anti-inflammatory, antipyretic, and analgesic properties (Vidhya and Narain, 2011). [26]Since wood apples are a seasonal and highly perishable fruit, they can be preserved by being processed into a variety of value-added goods, such as chutney, fruit bars, RTS, squash, nectar, pickles, jam, and pulp powder, so they can be used all year long. The fruit can be consumed raw, but because of its resinous flavour, it must be sweetened. The pulp of the ripe fruit is typically used to make delicious chutney, though it can also be eaten straight away after being sweetened. (2015) Anuradha K. [27]Due to their great nutritional value, wood apple fruit is widely renowned for its medicinal capabilities. 1980's Geda and Bokadia[28] observed the essential oil from wood apple fruits' antibacterial properties and noted that it was effective against 12 different human pathogenic microorganisms. (2000) Maiti and Mishra [29]have observed that the fruits of wood apple trees exhibit antivenom action. Hiccups can be treated with wood apple, which can be found in chutneys and sherbet. Research has shown that the wood apple's fruits, leaves, and stem bark have anti-tumor and antibacterial properties. Antioxidant and diabetic properties of wood apple. According to Patel et al. (2012), it works by lowering blood glucose and malondialdehyde levels. [30] Cathartics, laxatives, and purgatives are all included within the category of anti-constipation medications. While all three classes strive to increase defecation, their levels of action are different. In contrast to laxatives, which function more slowly to treat acute non-dietary constipation, purgatives have a greater action that causes more fluid to be evacuated from the rectum. Laxatives are therefore milder than purgatives. Even more potent than the two are cathartics that encourage colonic evacuation. Cathartics are therefore the most potent, followed by purgatives and laxatives. [31]Laxatives are composed of chemicals to increase stool motility frequency. [32] Due to their stimulatory action to defecate, which is brought about by enhanced water and electrolyte transport into the gut mucosa while also softening hardened faces, they are the most frequently recommended class of medications for constipation. Since most laxatives are available over-the-counter, they are frequently bought to treat constipation on one's own, which results in low drug compliance and effectiveness. [33, 34]

NatureNature

PLANT DESCRIPTION

An average tree can reach a height of 12 metres (40 ft). Even though it grows slowly and is a subtropical species, the tree can withstand a wide temperature range, from -6°C to 48.8°C. Thisplant is reproduced through seed. Almost any sort of soil will support the growth of the wood apple. It can easily survive extended droughts. Once established, it requires little maintenance. Seven years are needed for saplings to start bearing fruit. After flowering, the fruit takes 10 to 12 months to ripen.

VARIETIES

Two of the several wood apple kinds that are grown in India are highly well-liked: the yellow bael, which tastes sweet when ripe, and the kodbael, which is both sweet and sour. Both are quite beneficial medically. This fruit and its plant are the subject of extensive research by numerous pharmaceutical companies.

SEASON

In Malaysia, flowering takes place in February and March, the fruit ripens in October and November, and the leaves are lost in January. The fruit ripens in India between early October and March.

DISTRIBUTION

India, Sri Lanka, Pakistan, Java, and Malesia have all reported finding LimoniaAcidissima L. on a global scale. It is seen to happen in the desert regions of India. The states that have reported it are Punjab, Delhi, Rajasthan, Madhya Pradesh, West Bengal, Arunachal Pradesh, Maharashtra, Goa, Karnataka, Tamil Nadu, and Andhra Pradesh. This species is widely distributed throughout Indo-Malesia. All over the Indian plains, especially in the drier sections, it is cultivated for its fruits. [35]"

MORPHOLOGICAL CHARACTERISTICS:

The LimoniaAcidissima L. tree grows to a sizeable, deciduous, upright tree in India. It has a few rising upward branches that bend outward near the summit, where they are divided into thin, drooping branchlets."[36]". It is a slow-growing tree with a 9 m height that grows well in desert, warm areas up to 450 m elevation and frequently has rough, thorny bark. It is found throughout India. The spines are axillary, tiny, straight, and 2–5 cm long on a few of the zigzag twigs.

DESCRIPTION OF DIFFERENT PARTS OF LIMONIA ACIDISSIMAL

LimoniaAcidissima L. has alternate, deciduous, three to five-inch-long, dark green, leathery leaves. Born in small, loose panicles that are terminal or lateral, frequently minutely serrated, blunt, or notched, dull crimson, or greenish. The fruit is round to oval in shape and is 5-12.5 cm across. It has a woody, extremely hard peel that can be difficult to break. The fruit is greyish-white in appearance and has a scurfy peel that is around 6 mm thick. The pulp of LimoniaAcidissima L. is black, aromatic, and gooey. It is fragrant, resinous, astringent, acidic, or sweet-tasting and has numerous tiny, white seeds strewn throughout it.There are two different types, one with large, sweet fruits and the other with small, tart ones.

LimoniaAcidissima L. is a plant that has a pleasant scent. The 6 mm-thick, grayish-white rind has a rough texture. It has a woody, extremely hard exterior shell called the rind that is exceptionally difficult to crack open. The hard rind of the wood-apple fruit is broken with a hammer.[37]"

MEDICINAL USES:

- LimoniaAcidissima L. is commonly used as a liver and heart tonic in India. To treat poisonous insect bites and stings, the pulp is used as a poultice.
- Successful treatments for diarrhoea, dysentery, a sore throat, gum infections, and a cough include LimoniaAcidissima L.
- Traditionally, the stem bark of Limoniaacidissima is mixed with water and applied largely on the face (Yoganarasimhan, 2000). Regular application to the skin is supposed to keep it cool, smooth, fair, and well-textured, according to Patra, Mishra, and Chaudhuri (1988). It is also known to prevent skin cancer by blocking UV light.
- Minor skin lesions and spots are treated using the facial cosmetic "Thanaka," which is made from the pulp of L. acidissima (Bandara et al..[38]

PHARMACOLOGICAL ACTIVITY:

Wound Healing-

Using a methanol extract of LimoniaAcidissima L. fruit pulp as a screening agent, albino rates of either sex were utilised to evaluate the wound healing ability. When the extracts were applied to the wound in the excision wound model, the wound gradually shrank and needed a mean healing time of 16.0 +/- 0.8 days. Incision wound models treated with MELA (Methanol extract of fruit pulp) had higher wound breaking strength and shorter epithelization times. Different LimoniaAcidissima L. extracts have potent, dose-dependent wound-healing properties."[39]"

Antioxidant Activity-

Antioxidant activity was tested in a crude methanol extract of Limoniaacidissima L. stem bark "[40]". On the stable radical 1, 1-diphenyl-2-picrylhydrazyl (DPPH), the antioxidant activity of the partitionates was assessed. The crude methanol extract's chloroform soluble fraction (CL) has the greatest capacity to scavenge free radicals. The pet ether soluble fraction (PE) also showed significant antioxidant activity at the same time. By using the FRAP and DPPH radical scavenging assays, the methanol extract of LimoniaAcidissima L. fruit was also examined for its capacity to scavenge free radicals. Different Limoniaacidissima L. leaf extracts have been studied and shown to have in vitro antioxidant activity. [41-43].

Anti-bacterial Activity-

By using the agar well diffusion method, the antibacterial activity was assessed against Gram-negative and Gram-positive bacteria. Hexane extract was found to be less active, whereas chloroform extract displayed mild to moderate activity and methanol extract shown good antibacterial activity with substantial inhibition zones. [44]Using the disc diffusion method, the antimicrobial activity of methanol extracts from LimoniaAcidissima L. plant parts was evaluated against Escherichia coli and Staphylococcus aureus. Different parts' extracts displayed varying levels of anti-microbial activity. In general, plant extracts from every section of the plant efficiently restrained the development of both gramme positive and gramme negative bacteria. The pulp extract from L. acidissima's 5 investigated parts (bark, leaf, shell, pulp, and seed) had the strongest inhibitory impact on both bacteria. "[45]".

To test the anti-bacterial effectiveness of dried pulp and rind, three gramme positive (Staphylococcus aureus, Staphylococcus epidermidis, and Bacillus subtilis) and one gramme negative (Proteus mirabilis) bacteria were utilised. It was discovered that the pulp's methanol extract had the strongest antibacterial activity against Staphylococcus epidermidis, Staphylococcus aureus, and Bacillus subtilis. Along with having antibacterial properties against Staphylococcus aureus and Staphylococcus epidermidis, LimoniaAcidissima L.'s rind also has "[46]".

Anti-fungal Activity-

The various extracts of limoniaacidissima L. fruit pulp showed antifungal efficacy against several pathogenic fungi (petroleum ether, chloroform, methanol, and aqueous). [47]"

EFFECT OF ACTIVE CONSTITUENTS:

1) **Flavonoids** - Polyphenolic substances called flavonoids are found in nature. Flavonoids are secondary plant metabolites that have antioxidant properties and share the chromane ring with tocopherols. Iron chelation, direct scavenging of oxygen and nitrogen free radicals, suppression of oxygen radical-producing enzymes, and reduction of leukocyte adherence to the blood vessel wall during tissue inflammation and reperfusion are the main mechanisms involved in this action. Flavonoids play a key role in the ageing process of the skin. By preventing extracellular matrix-degrading enzymes like collagenase, elastases, and hyaluronidases from breaking down the extracellular matrix,

flavonoids like kaempferol postpone skin ageing. “[48]”.The best antioxidant activity and rancidity protection come from flavonoids. The antioxidant action of LimoniaAcidissima L. is due to the presence of ascorbic acid in its pulp. Additionally, flavonoids have anti-fungal, anti-bacterial, and anti-microbial properties. According to reports, quercetin totally prevents Staphylococcus aureus from growing. “[49]”.

2) **Tannins** In addition to proteins, polysaccharides, alkaloids, nucleic acids, and minerals, tannins are a heterogeneous collection of high molecular weight polyphenolic chemicals. Gallotannins, ellagitannins, complex tannins, and condensed tannins are the four types of tannins that are separated based on their structural makeup. In 1905, (Maximilian Nierenstein) investigated the natural tannins present in many plant species. “[50]”.

Cosmetics-

- Precipitate protein, found in tannin, is used to treat burns and protect irritated skin surfaces.
- Tannins have antibacterial, antioxidant, and astringent properties.
- Tannins delay the ageing process of the skin.
- Tannins also function to stop hair loss. [51]

3) **Saponins**

Saponins are bioactive substances that are mostly made by plants. Chemically, they exist as polycyclic triterpenes or steroid glycosides. They can interact with cell membranes and lower the surface tension of an aqueous solution due to their lyobipolar characteristics. The name "saponin," which is derived from the Latin word "sapo" and refers to the creation of stable soap-like foam in aqueous solution, derives from this process. “[52]”

Cosmetics-

- Saponins are known as natural surfactants; in aqueous solutions like soap, they produce stable foam.
- They serve as a foaming agent in toothpaste, liquid detergent, and shampoo.
- Emulsifiers and long-lasting foaming agents both use saponins.
- Cosmetic products with saponin extract as an active ingredient have anti-oxidant, anti-aging, and regenerative qualities. “[53]”.

4) Alkaloids

The term "alkaline" was once used to denote any base that contained nitrogen, and this is where the name "alkaloids" comes from. They are typically organic bases that combine with acids to form salts, which, when soluble, result in alkaline solutions. Alkaloids are a class of chemical substances that exist in nature and primarily include basic nitrogen atoms. Some related compounds with neutral or even mildly acidic properties are also a part of this group. “[54]”

Cosmetics-

- Pyridine alkaloids have been found to present strong antimicrobial properties and have antioxidant activities because of their capacity to act as free radical scavengers, hydrogen donors, or electron or metal chelating activity"[55].
- Alkaloids are responsible for anti-bacterial and anti-fungal activity.
- Alkaloids provide a warming effect that can be applied, for example, to feet.
- Alkaloids combat wrinkles.
- Alkaloids also help in Skin-tightening” [56]”.

1. PH

Utilising a digital pH metre that was standardised with buffer solutions of 4.0 and 7.0, fresh fruit's PH was measured [57]. Fresh fruit was smashed using a pestle motor to determine pH, and the resulting solution was utilised to assess pH.

2. Visual color

A digital chronometer (Konica Minolta R-400/410 digital chronometer) was used to measure the visual colour of fresh fruit, tray-dried powder, and lyophilized powder.) [58].

3. Total soluble solids

Using a handheld refract ometer (0-90 0Brix), the total soluble solids (TSS) of fresh fruits and processed goods were calculated at room temperature (25 oC). Results of a three-fold reading were represented as Brix (0Brix) degrees.

4. Treatable acidity

Fresh fruit's treatable acidity was assessed by placing a three-gram sample in a beaker with 100 ml of distilled water and heating it for an hour. After cooling, filtering was done, and 500 ml of distilled water was used to prepare the final

volume. A 5 ml aliquot of the extract and a few drops of phenolphthalein indicator were then put to a 50 ml conical flask. The titer value was recorded when this was titrated against 0.1 N NaOH until a faint pink colour persisted for 30 seconds. The average of three measurements of the acidity that can be treated was reported as percent citric acid.

5. Moisture content

Five grammes of the sample (pulp, seeds, and whole fruit) were placed in clean, pre-weighed petri plates before being dried in a hot air oven at 100°C for 5–6 hours, or until a constant weight was achieved. Weight of petri plates and samples were recorded for calculation after chilling in the desiccator.

6. Ash content

Five grammes of the sample (pulp, seeds, and entire fruit) were placed in weighted dried silica crucibles and heated on a hot plate until the sample turned black or the smoke stopped. The charred sample was then placed in a muffle furnace that had been preheated to 550 oC, where it remained for 4–5 hours or until white coloured ash was formed. In a desiccator, crucibles were cooled, and weight was recorded.

7. Total Ascorbic Acid

To extract ascorbic acid, two grammes of each sample were placed in a conical flask and mixed with 20 millilitres of a meta-phosphoric-acetic acid solution. The mixture was transferred to a volumetric flask after being filtered using Whatman filter paper. In a hurry, 2, 6 dichlorophenol indo-phenol solution was titrated with 2 ml of the filtrate extract and 5 ml of meta-phosphoricacetic acid solution until a light, definite rose-pink colour remained for more than 5 seconds.

8. Reducing sugar

The approach proposed by Ranganna was used to estimate the total amount of reducing sugars in the sample using Fehling's 'A' and 'B' solutions.

9. Microbial growth

Using a malt extract medium and the conventional plate count method, the microbial contamination and growth were assessed. After 48 hours of incubation at 38° C with sterile distilled water as the control, the plate was counted. [59].

10. Total Phenolic content

The Folin-Ciocalteu test method by UV vis mass spectrophotometer was used to assess the total phenolic content of the fruit sample extracts.In a volumetric flask (25 ml), the reaction mixture of 1 ml of extract and 9 ml of distilled water was taken. The mixture was treated with one millilitre of the Folin-Ciocalteu phenol reagent by vigorously shaking. The mixture was treated with 10 ml of a 7% sodium carbonate (Na_2CO_3) solution after five minutes. Deionized water was then added to the mixture to make a total volume of 25 ml, and a spectrophotometer was used to measure the absorbance of the test and standard solutions in comparison to the reagent blank at 650 nm. [60].

Pharmacological Effects

Wood apple fruit has several pharmacological effects that are attributed to its chemical constituents. Some of the main pharmacological effects of wood apple fruit include:

1. Antioxidant: The wood apple fruit has strong antioxidant capabilities due to its high concentrations of tannins, flavonoids, and vitamin C. Cells are helped by antioxidants to resist oxidative stress and damage brought on by free radicals.
2. Anti-inflammatory: The wood apple fruit includes a number of polyphenols that have anti-inflammatory characteristics, including gallic acid and ellagic acid. These substances might aid in reducing bodily inflammation, which can be a factor in a number of chronic disorders.
3. Anti-diabetic: Research suggests that wood apple fruit may improve insulin sensitivity and lower blood glucose levels, which may have anti-diabetic properties.
4. Anti-cancer: According to numerous studies, the wood apple fruit's polyphenols, particularly ellagic acid, offer anti-cancer qualities. It has been demonstrated that these substances prevent the growth and division of cancer cells.
5. Immunomodulatory:Wood apple fruit has been demonstrated to have immunomodulatory properties, which means it may aid to control and enhance the immune system's performance.
6. Antimicrobial: Research on wood apple fruit has revealed that it is particularly effective against bacterial strains including Staphylococcus aureus and Escherichia coli.
7. Gastroprotective: The wood apple fruit is gastroprotective, which means that it can help to protect the stomach lining and lower the risk of ulcers. This is due to the high quantities of tannins in the fruit.

Overall, the pharmacological effects of wood apple fruit are attributed to its rich chemical composition, which makes it a potent natural remedy for various ailments. However, more research is needed to fully understand the mechanisms of action and potential clinical applications of wood apple fruit. [61-65]

Conclusion

According to the current study, defatted C. lanatus and L. acidissima seed flours are good sources of protein and other nutrients, like minerals. These features are crucial and imply that these flours would be suitable for use as a matrix or as an ingredient in other food fortification preparations. Given the excellent functional characteristics of these flours, this is extremely likely. The defatted flours' thermal stability, spherical morphology, and amorphous nature will be advantageous for food system development or inclusion. According to the results of the current study, wood apple chutney is superior in terms of bioactive compounds like phenolic content and its antioxidant capabilities, which increase the product's quality and create a substantial opportunity for the marketing of goods made from the underutilised fruit. The purpose of the study was to ascertain how the storage period of wood apple chutney affected its physicochemical properties, total phenolic content, and antioxidant activity. The results of the study suggest that consumers accepted chutney based on its sensory qualities and that physicochemical properties degraded over time. During the storage period, a gradual decrease in the value of total phenolic content and antioxidant activity was seen. Learn more about improved atmospheric packing that improves or keeps the functional qualities throughout storage.

REFERENCES

[1] Pandey A, Gupta RK. Evaluation of nutritional, phytochemical, antioxidant and antibacterial activity of exotic fruit Limoniaacidissima.Journal of Pharmacognosy and Phytochemistry. 2014; 3(2):130-132.

[2] Namdev, Abhayawardhane, Gunatilaka A, Bandara BR, Wijeratne E. Antifungal activity, acid and sugar content in the wood apple (Limoniaacidissima) and their relation to fungal development. Plant pathology. 2015; 38(2):258-265.

[3] Kumar A, Deen B. Studies on preparation and storage of jelly from wood apple (Limoniaacidissima) fruits. Journal of Pharmacognosy and Phytochemistry. 2017; 6(6):224-229.

[4] Adikaram M, Sundha GS. Studies on development of value added product from wood apple fruits. CentralFood Technological Research Institute Resources. 2007; 6(2):76-79.

[5] Ratnayake S, Bajrang L. Manual analysis of fruits and vegetables. Food Research Laboratory, Mysore, India. 2009; 3(2):86-89.

[6] Singh R, Arjun C. Nutritive value of Indian underutilized fruits. Food and Nutrition paper. 2017; 15(6):126-129.

[7] Vijayakumar K, Patange J. Drying character and quality evaluation for fruit pulp powder of wood apple. Food Science. 2013; 4(2):45-49.

[8] Kumar D, Bhosle R. Preparation of squash from wood apple fruit and its storage studies. Harayana Journal Horticulture Science. 2017; 2(9):98-101.

[9] Singhania N, Ray AB. Effect of Drying Techniques on Physicochemical Properties of Wood Apple (Limoniaacidissima). Journal of Agricultural Engineering and Food Technology. 2019; 6(1):9-12

[10] Veeraraghavathatham W, Samung R. Studies on the nutritional and organoleptic character of wood apple fruit (Limoniaacidissima). Journal of Pharmacognosy and Phytochemistry. 2008; 5(2):139-142.

[11] Kumar Z, Udipi SA. Study on underutilized fruit and its health benefits. Edible Medicinal and Non-Medicinal Plants, 2004; 2(8):231-235.

[12] Vasant RA, Narasimhacharya, Amaravadi VRL. Limonia fruit as a food supplement to regulate fluoride-induced hyperglycaemia and hyperlipidaemia. Journal of Science and Food Agriculture, 2012.

[13] Qureshi AA, Kumar K, Eswar, Shaista O. FeroniaLimonia – A path less travelled. International Journal of Research in Ayurveda & Pharmacy. 2010; 1(1): 98-106.

[14] Vidhya B, Rao S. Physio-chemical characteristics, sensory quality of wood apple fruit. Indian Food Packer. 2011; 52(9):36-42.

[15] Bhuiyan MHR. Pickle and Chutney Development from Fresh Hog Plum (Spondiasdulcis).Journal of Environmental Science and Natural Resources. 2012; 5(2):67-72.

[16] Klaschik, E.; Nauck, F.; Ostgathe, C. Constipation - Modern Laxative Therapy. Support Care Cancer Internet]. 2003 Nov 20 [cited 2022 Jul 13];11(11):679–685. Available from https://link.springer.com/article/10.1007/s00520-003-0525-x

[17] Santucci, N. R.; Chogle, A.; Leiby, A.; Mascarenhas, M.; Borlack, R. E.; Lee, A.; Perez, M.; Russell, A.; Yeh, A. M.,Non-pharmacologic Approach to Pediatric Constipation. Complementary Therapies in Medicine 2021,59,102711. 10.1016/j.ctim.2021.102711

[18] Bharucha, A. E.; Lacy, B. E. Mechanisms, Evaluation, and Management of Chronic Constipation HHS Public Access. Gastroenterology. 2020, 158(5), 1232–1249.

[19] Adikaram NKB, Abhayawardhane Y, Bandara BMR, Gunatilaka AAL, Wijeratne EMK: Anti-fungal activity, acid, and sugar content in the wood apple (Limoniaacidissima) and their relation to fungal development. Plant Pathol 1989; 38: 258-65.

[20] Husaini M, Saati EA, Putri DN. Study of utilization three varieties of mango and concentration of apple vinegar towards physicochemical characteristics of mango chutney. Journal of food technology and halal science. 2019, 4-14.

[21] Dorajeerao AVD, Priyanka N, Sudhavani V, Umakrishna K. Physico-chemical characters and sensory evaluation of jamun based blended squash beverages during storage. Plant Archive. 2015; 15(2):939-946.

[22] Hamid, Thakur NS, Kumar P, Thakur A. Studies on preparation and preservation of Ready–to-Serve (RTS) Beverage from underutilized mulberry (Morus alba L.) fruits and its quality evaluation during storage. International Journal of Current Microbiology and Applied Sciences. 2017; 6(9):1067-1079.
[23] Sharma S, Gehlot R, Singh R, Rekha, Sindhu R. Studies on development and evaluation of bael-mango chutney. International Journal of Chemical Studies. 2019; 7(3):5183-5185.
[24] Deng M, Deng Y, Dong L, Ma Y, Liu L, Huang F et al. Effect of Storage Conditions on Phenolic Profiles and Antioxidant Activity of Litchi Pericarp. Molecules. 2018; 23: 2276; http://dx.doi.org/10.3390/molecules230922764
[25] Joshi H, Kochhar A, Boora RS. Development and Quality Evaluation of Chutney from New Varieties of White and Pink-Fleshed Guava.International Journal of Current Microbiology and Applied Science. 2017; 6(10):1062-1068.https://doi.org/10.20546/ijcmas.2017.610.128
[26] Vidhya R, Narain A. Development of Preserved Products Using Under Utilized Exploited Fruit, Wood apple (Limoniaacidissima L.). American Journal of Food Technology. 2011;6(4):279-288.
[27] Amerada K, Seihari D. Studies on processing of wood apple, Krishikosh. 2005.
[28] Geda A, Bokadia MM. Antimicrobial activity of essential oils on human pathogenic bacteria, Science and culture. 1980;46(1):33-35.
[29] Maiti S, Miashra TK. Anti-venom drugs of Santals, Savars and Mahatos of Midnapore district of West Bengal, India, Ethnobotany. 2000;12:77-78.
[30] Patel DK, Kumar R, Laloo D, Hemalatha S. An overview on its pharmacological aspects and reported medicinal plants having anti diabetic activity.Asian Pacific Journal of Tropical Biomedicine. 2012;2:411-420
[31] Lakshmanan, M. Drug Therapy for Constipation. Introduction to Basics of Pharmacology and Toxicology [Internet]. 2021 [cited 2022 Sep 4]; 593–604.
[32] Rtibi, K. Laxative and anti-purgative Bioactive Compounds in Prevention and Treatment of Functional Gastrointestinal Disorders, Constipation and Diarrhea Digestive Physiology and Nutrition View Project Physiology and Phytotherapy View Project. 2018 [cited 2022 Sep 1]
[33] Werth, B. L.; Christopher, S. A.; Wakil, S.; Wakil, S.; Wakil, S. Clinical Medicine Laxative Use in the Community: A Literature Review. J. Clin. Med. Internet]. 2021;10:143. Available from, (1) 10.3390/jcm10010143
[34] Kang, S. J.; Cho, Y. S.; Lee, T. H.; Kim, S. E.; Ryu, H. S.; Kim, J. W.; Park, S.-Y.; Lee, Y. J.; Shin, J. E. Medical Management of Constipation in Elderly Patients: Systematic Review. J. NeurogastroenterolMotil. Internet]. 2021. [cited 2022 Jul 27];27 4 495–512. doi:10.5056/jnm20210.
[35] ENVIS Centre on Medicinal Plants, Plant Details for a Limoniaacidissima L. (http://envis.frlht.org/plantdetails/4dae30264bb6a6605015c71c7217e0c0/cd8e663947c36853c49538fba38af83)
[36] Awadhesh Kumar and BhagwanDeen, Studies on Bio-Chemical Changes in Wood Apple (Limoniaacidissima L.) Fruits during Growth and Development, International Journal of Current Microbiology and Applied Sciences, ISSN: 2319-7706, Volume 6 Number 8 (2017), pp. 2552-2553
[37] Plant Profile, Chapter 3, University Department of Pharmaceutical Sciences, pp. 21-24 (https://shodhganga.inflibnet.ac.in/bitstream/10603/118945/12/12_chapter%203.pdf)
[38] Plant Profile, Chapter 3, University Department of Pharmaceutical Sciences, pp. 26 (https://shodhganga.inflibnet.ac.in/bitstream/10603/118945/12/12_chapter%203.pdf)
[39] K Ilango and V Chitra, Wound Healing and Anti-oxidant Activities of the Fruit Pulp of LimoniaAcidissima Linn (Rutaceae) in Rats, Tropical Journal of Pharmaceutical Research June 2010; 9 (3): 223-230
[40] SadiaShermin, FahimaAktar, MoniraAhsan and Choudhury M. Hasan, Antioxidant and Cytotoxic Activitiy of Limoniaacidissima L., Dhaka Univ. J. Pharm. Sci, 2012 (June), pp. 75-77
[41] SureeNanasombat, KanitthaKhanha, JirapornPhan-im, JutatipJitaied, SaranyaWannasomboon, SarissaPatradisakorn and AnusaWongsil, antimicrobial and antioxidant activities of thai local fruit extracts: application of a selected fruit extract, phyllanthusemblicalinn. as a natural preservative in raw ground pork during refrigerated storage, tojsat: The Online Journal of Science and Technology- January 2012, Volume 2, Issue 1, pp. 1-5
[42] Attarde D L, Chaudhari B J and Bhambar R S, Phytochemical investigation and in vitro antioxidant activity of extracts from leaves of Limoniaacidissimalinn. (Rutaceae), Journal of Pharmacy Research 2011, 4(3), pp. 766-768
[43] Merinal, S. and Viji Stella Boi, G. , In vitro antioxidant activity and total phenolic content of leaf extracts of Limoniacrenulata (Roxb.), J. Nat. Prod. Plant Resour., 2012, pp. 209-214.
[44] G. Kishor NAIDU, B. SUJATHA, K. Chandra Sekhar NAIDU, In vitro Antibacterial Activity Analysis of Leaves of Limoniaacidissima, NotulaeScientiaBiologicae 2014, pp. 155-157
[45] Asha Thomas and N. R. Ponnammal, Preliminary Studies On Phytochemical And Antibacterial Activity Of Limoniaacidissima L. Plant Parts, Ancient Science of Life, December 2005, pp.57-61
[46] ShipraPandey, GouriSatpathy, Rajinder K. Gupta, Evaluation of nutritional, phytochemical, antioxidant and antibacterial activity of exotic fruit “Limoniaacidissima”, Journal of Pharmacognosy and Phytochemistry 2014, pp. 81-88.
[47] Jayashree V H, Londonkar R. Comparative phytochemical studies and antimicrobial potential of fruit extracts of Feronialimonia Linn. Int Journal of Pharmacy and Pharmaceutical Sciences, Vol 6, 2014, pp. 731-734

[48] Mayuri A Parate, Dr. Nibha D Bajpai, Dipalini D Walke, Role Of Syzygium Cumini (Jamun) In Cosmetic, International Journal of Scientific Development and Research, June 2019, pp. 192-199
[49] AR Tapas, DM Sakarkar, and RB Kakde, Flavonoids as Nutraceuticals: A Review, Tropical Journal of Pharmaceutical Research, September 2008, pp. 1089-1096.
[50] Praveen Kumar Ashok, KumudUpadhyaya, Tannins are Astringent, Journal of Pharmacognosy and Phytochemistry, Vol 1, pp. 45-50.
[51] HimanshuJaiswal, Om Ji Singh, AnkitChauhan, Maneesh Kumar Sahu, Surya Prakash DV, A review on tannins, European Journal of Biotechnology and Bioscience, May 2018, Vol 6, pp. 16-17.
[52] Mayank Thakur, Matthias F Melzig, Hendrik Fuchs, Alexander Weng, Chemistry and pharmacology of saponins: special focus on cytotoxic properties, Botanics: Targets and Therapy 2011, pp. 19-29.
[53] Bruno Burlando, LuisellaVerotta, Laura Cornara, and Elisa Bottini-Massa.Traditional Herbal Medicines for Modern Times. Herbal Principles in Cosmetics Properties and Mechanisms of Action by Taylor and Francis Group, LLC CRC Press is an imprint of Taylor & Francis Group, an Informa business.2010 (9-26).
[54] Arpita Roy, A Review on the Alkaloids an Important Therapeutic Compound from Plants, International Journal of Plant Biotechnology, Vol 3, pp. 1-9
[55] R J Molyneux , R J Nash , N Asano, Alkaloids: Chemical and Biological Perspectives, Vol. 11, Pelletier SW, ed. Pergamon, Oxford, 1996; 303.
[56] Dr. Hans Lautenschlager, Alkaloids in cosmetic applications, Kosmetik International 2014 (12), pp. 22-25
[57] Ranganna, S. (2010). Handbook of analysis and quality control for fruit and vegetable products.Tata McGraw- Hill Education.
[58] Yam, K. L., &Papadakis, S. E. (2004). A simple digital imaging method for measuring and analyzing color of food surfaces. Journal of food engineering, 61(1), 137-142
[59] Ranganna, S. (2010). Handbook of analysis and quality control for fruit and vegetable products.Tata McGraw- Hill Education.
[60] Singleton, V. L., & Rossi, J. A. (1965). Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents.American journal of Enology and Viticulture, 16(3), 144-158.
[61] Gupta VK, Sharma SK. Wood apple (Limoniaacidissima Linn.): An overview of its botany, cultivation, chemistry and pharmacology. African Journal of Traditional, Complementary and Alternative Medicines. 2011;8(5S): 208-219. doi: 10.4314/ajtcam.v8i5S.2
[62] Reddy PR, et al. Chemical composition and pharmacological properties of wood apple (Limoniaacidissima Linn.): A review. International Journal of Pharma and Bio Sciences. 2012;3(2): 126-133.
[63] Datta S, et al. Potential health benefits of wood apple (Limoniaacidissima Linn.). International Journal of Pharmaceutical Sciences and Research. 2019;10(1): 28-34. doi: 10.13040/IJPSR.0975-8232.10(1).28-34
[64] Prasad K, et al. LimoniaacidissimaLinn.: A review of its traditional uses, phytochemistry, pharmacology and toxicology. Journal of Ethnopharmacology. 2020;254: 112669. doi: 10.1016/j.jep.2020.112669
[65] Roy S, et al. Terminaliabellirica: Chemical and pharmacological aspects. Pharmacognosy Reviews. 2010;4(7): 195-203. doi: 10.4103/0973-7847.70916.