



# **Nutraceutical Value and Therapeutic Applications of Indian Heritage Fruits: A Review**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author KJ led the execution of the review, including the conceptual framework, and the drafting of the manuscript. Author JV is responsible for collecting and analyzing the literature collection, as well as reviewing and editing the manuscript to ensure accuracy and clarity. Author VKR contributed to the critical revision of the manuscript and assisted in the preparation of visual content such as tables. Author AR provided essential resources and supervised the entire review process to ensure its completion and adherence to standards. Author PK reviewed and edited the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

This review delves into the nutraceutical value and therapeutic uses of bael, woodapple, aonla, ber, and karonda fruits, revered for their medicinal properties across traditional medicine systems. Enriched with essential nutrients and bioactive compounds like phenolics, flavonoids, and alkaloids, they offer diverse health benefits, including immune support and digestive health enhancement. Through a meticulous analysis of scientific literature, the review underscores their potential in preventive and holistic healthcare. By acknowledging and leveraging their nutraceutical and therapeutic potentials, individuals and communities can endeavor towards improved health and well-being.

*Keywords: Fruits; nutritional profile; bioactive compounds; therapeutic values; health benefits.*

## 1. INTRODUCTION

The increased demand for natural products and plant-based medicine highlights the importance of nutraceuticals that offer health benefits beyond basic nutrition. Among these, underutilized fruits play a vital role due to their abundance of essential nutrients and bioactive compounds. India, with its rich biodiversity, has a wide range of heritage fruits that have been used in traditional medicine and dietary practices.

Underutilized fruits provide vital food, vitamins, and minerals, alongside contributing to livelihoods due to their medicinal properties [13,35]. Despite being used in local medicine, many of these fruits lack domestication and human selection efforts, restricting their cultivation mainly to the wild. Underutilized crops, although less explored in terms of promotion and research, thrive in diverse and challenging conditions [4,10]. Their importance varies across different crops and regions but can be significantly enhanced through increased awareness. With a rich history of usage, underutilized wild edible plants are increasingly recognized for their high nutritional value, as evidenced by ongoing global research efforts [31].

India is the origin of several underutilized fruits, many of which possess remarkable medicinal and therapeutic properties. This review delves into a selection of these indigenous fruits, examining their nutritional profiles, bioactive compounds, and diverse health benefits [53,57]. By highlighting the medicinal and therapeutic potential of these fruits, this review underscores their significance in both traditional and modern healthcare practices [11,16].

Bael, renowned for its efficacy in treating digestive disorders, is abundant in vitamins and

phenolic compounds, offering a broad spectrum of health benefits (Venthodika et al., 2021). Wood apple, distinguished by its unique flavor and nutritional composition, has traditionally been used to manage diabetes and support liver health [65]. Aonla, also known as Indian Gooseberry, is acclaimed for its high vitamin C content and strong antioxidant properties, making it exceptionally effective in enhancing immunity and preventing chronic diseases [64]. Ber, or Indian Jujube, is rich in vitamins and minerals and is esteemed for its anti-inflammatory and hepatoprotective properties [63]. Finally, Karonda is acknowledged for its antimicrobial and cardioprotective benefits, which are attributed to its diverse phytochemical profile [40,43].

This review aims to consolidate the current knowledge on the nutritional and bioactive composition of these fruits, their traditional and modern therapeutic applications, and the underlying mechanisms of their health benefits. By doing so, it seeks to underscore the potential of these heritage fruits as nutraceuticals and their role in promoting health and wellness in contemporary society.

## 2. NUTRACEUTICAL POTENTIAL OF INDIGENOUS FRUITS

### 2.1 Bael

The bael tree, deeply rooted in Indian history and mythology, has long been recognized for its therapeutic value in traditional medicine. Modern research confirms its effectiveness, attributing to its antioxidant, and antimicrobial properties. Bael addresses various health concerns including gastrointestinal, and cardiac issues, while also exhibiting hepatoprotective, radioprotective, anti-diabetic, and wound-healing properties [71].

**Table 1. Medicinal properties of bael**

Parts of Bael	Bioactive Compounds	Medicinal Properties and Therapeutic Properties	References
Fruits	Marmelosin	Anthelmintic and antibacterial activity	[5,58,18,68]
	Auraptin	Treatment of hypertension	[58, 21, 68]
	Psoralean	Antispasmodic	
	Tannin	Diarrhoea	
Roots and Bark	Fagarine	Abortifacient property	[81,17]
	Marmin	Antiulcer activity	
Leaves	Cuminaldehyde	Antifungal, antibacterial and anticancer properties	[20,55,39]

(Chhetri, 2021)

**Table 2. Chemical composition of wood apple**

Characters	Composition
Moisture (%)	72.00 ± 2.04
Protein (%)	7.14 ± 0.24
Fat (%)	1.45 ± 0.09
Carbohydrates (%)	7.24 ± 0.12
Ash (%)	4.98 ± 0.02
Calcium (%)	0.12 ± 0.07
Phosphorus (%)	0.07 ± 0.002
Iron (%)	1.0 ± 0.03

(84)

**Table 3. Pharmacological activities of Wood Apple**

Part	Pharmacological activities	References
Fruit	Anti-tumor activity	[61; 22]
Fruit	Anti-diabetic activity	[19; 54]
Fruit pulp	Wound healing property	[62; 89]
Leaves	Anti-microbial activity	[8; 32]
Seeds	Anti-microbial activity	[76]
Root and bark	Hepatoprotective activity	[27]
Fruit	Antioxidant activity	[51]
	Neuroprotective activity	[56]

The subtropical fruit *Aegle marmelos* L., commonly referred to as Bael is a member of the Rutaceae family. The sacred Tripatra tree's leaves are vital in offerings to Lord Shiva. Its root, bark, leaf, flower, and fruit find diverse uses. While wild fruits are smaller and less commercial, cultivars like Kagzi Gonda, Gonda no 1, Gonda no 2, Kagzi Etawah, Mirzapuri, and Baghel are cultivated. [66]. Research on bael fruit indicates its rich nutritional composition, encompassing a diverse array of phytochemicals such as phenolic acids, flavonoids, alkaloids, tannins, and coumarins. Additionally, bael contains amino acids, fatty acids, various organic acids,

minerals, carbohydrates, vitamins, and fibers, rendering it a highly nutritious fruit with significant health advantages [9]. Table 1 indicates the medicinal properties of bael.

## 2.2 Wood Apple [84]

The botanical name of the Wood apple is *Feronia limonia* Groff belongs to the Rutaceae family. The native of wood apple is India. The other names of wood apple are elephant apple; monkey fruit; curd fruit and kathbel. The tree is small to medium size, deciduous with thorny branches,

hardy in nature and can withstand salt and drought [85]. The fruit type is Amphisarca which is a hard shelled berry and fruit has sweet aromatic edible pulp [41]. The processed products of wood apple are powder, jam, RTS, pickle, candy, preserve, squash, toffee and wine [88]. The medicinal uses of wood apple fruit includes several treatments such as cardiac tonic, Sore throat, peptic ulcer, tumors, hepatitis, asthma, diarrhoea, liver problems and blood purification. Wood apple leaves are used to cure diarrhoea, dysentery, breast cancer, uterus cancer, respiratory disorders, Carminative and Hepatoprotective activity. The bark is used to cure venomous wounds, constipation, diarrhoea and Haemorrhage [6; 14; 49]. Tables 2 and 3 indicates chemical composition and pharmacological activities of wood apple.

### 2.3 Aonla [15]

Aonla, also known as Indian gooseberry (*Emblica officinalis* Gaertn.), is a member of the Euphorbiaceae family, revered for its medicinal properties since ancient times in India. This indigenous fruit of the Indian subcontinent is widely utilized in the Indian System of Medicine. Aonla fruits are characterized by their round shape, ribbed texture, and pale green color. The fruit's surface is shiny, divided into six segments by pale liner grooves, and varies in size from small marble to large plum. Despite its nutritional value, the raw fruit's high acidity and astringent taste make it unpalatable to consumers [69]. Aonla, also known as Amla, Adiphal, Amlaki, and Nelli in various languages, is commonly grown in arid zones and saline soils. It is a major component of traditional medicines like Chyawanprash. The fruit is rich in vitamin C (600 mg/100g) and possesses various medicinal properties. Fresh fruit is used to treat dysentery, fevers, indigestion, and eye inflammation. Dried fruit acts as an astringent, stomachic, and blood purifier, beneficial for diarrhea, dysentery, and anemia. A decoction of dried fruits is effective for gonorrhoea, and when combined with iron, it treats jaundice and dysentery. Aonla seeds are infused for fever, diabetes, and eye diseases, while the oil extracted from seeds treats dandruff and darkens hair. The smoke from burning seeds is inhaled to relieve asthma and bronchitis. Overall, aonla fruit and seeds offer diverse therapeutic benefits for various ailments [34]. Table 4 indicates the medicinal uses of aonla.

### 2.4 Ber

The ber (*Zizyphus jujuba* Lam) tree, a thorny small tree native to India, has been cultivated since ancient times for its highly nutritious fruits, rich in vitamin C, A, and B12, with almost all parts possessing medicinal properties. The roots are bitter, cooling, and tonic, beneficial for cough, fever, wounds, and ulcers, while stem bark treats dysentery, diarrhea, and boils. Leaves are used for various ailments including stomatitis, wounds, asthma, and obesity, and boiled leaves are applied to promote suppuration in boils and abscesses. Fruits are sour, sweet, and cooling, beneficial for digestive issues, constipation, and wounds. Seeds, acrid and soporific, are used for encephalopathy, cough, and insomnia, with kernels applied as a liniment for rheumatism [34]. Table 5 indicates the medicinal uses of ber.

### 2.5 Karonda

Karonda (*Carissa carandas* L) is an underutilized fruit belongs to Apocyanaceae [90] which is commonly known as Christ thorn and it is an evergreen spiny shrub. The native of karonda is Indo-Malaysia. It is suitable for tropical and subtropical climate. *Carissa carandas*; *Carissa grandiflora*; *Carissa ovata*; *Carissa grandiflora*; *Carissa edulis*; *Carissa macrophylla*; *Carissa spinarum*; *Carissa bispinosa*; *Carissa diffusa* are the cultivated species of Karonda [47; 73]. Flowers are white in colour and the fruit type is berry. Flowering takes place in March-April and fruiting occurs in October-November. Unripe fruits are white in colour and ripe fruits are purplish in colour [44]. Karonda is rich source of Iron (39.1%) and used to cure anaemia [33; 60]. It is also used to cure malaria, head ache, cold, cough, leprosy, nervous disorders and myopic spasms [23]. Karonda is sexually propagated by seeds and asexual propagation through cuttings, air layering and inarching. The value-added products prepared from karonda are curries, condiments, jam, syrup and squash. Fruits contain high amount of pectin and is suitable for jelly making [33,87]. The varieties of karonda include Pant Manohar, Pant Suvarna and Pant Sudarshan released by GBPUA&T (Govind Ballabh Pant University of Agriculture and Technology), Pantnagar; Thar Komal released by CIAH, Ghodhra (Central Institute for Arid Horticulture) [75]; Maru Gaurav released by ICAR-CAZRI (Central Arid Zone Research Institute), Jodhpur [74]. Tables 6 & 7 indicates the medicinal properties of karonda and extraction methods.

**Table 4. Medicinal uses of aonla**

Part	Medicinal uses	References
Fruit extract	Cancer treatment	[1]
	Diabetics treatment	[80]
	Immunomodulation	[15]
	Memory enhancer	[86]
	Cholesterol and Dyslipidemia treatment	[30; 2]
	Snake venom neutralizer	[1]
	Antimicrobial activity	[77]
	Antigenotoxicity	[77]
	Antimutagenicity	[72]

**Table 5. Medicinal uses of ber**

Part	Medicinal and therapeutic properties	Reference
Fruit	Anticancer property	[25]
	Antidiabetics property	[28]
	Hepatoprotective	[12]
	Antimicrobial Activity	[82]
	Anti-inflammatory Effect	[26]
	Antispastic Effect	[26]
	Antiallergic	[78]

**Table 6. Bioactive compounds and medicinal properties of Karanda**

Parts of Karonda	Bioactive compounds	Medicinal properties and therapeutic properties	References
Root	Carrissone and caridone	Antibacterial property	[36] [46]
	Urosolic acid and methyl ester	Anticancer activity and cardioprotective compound	[37,50,67] [46]
Leaf	Oleanolic acid	Anti-inflammatory and antihyperlipidemic properties	[38,46]
Wood and bark	Carindone	Antibacterial activity	[36]
Fruit	Linalool	Antimicrobial effect	[48]
	Coumarin	Anti-HIC, Anti-tumor, Anti- hypertension, and Anti-inflammatory	[52,70;59,38,45]

**Table 7. Medicinal properties of Karanda**

Part used	Bioactive compounds extraction method	Medicinal property	References
Karonda leaves	Methanolic extraction	Anti- inflammatory and anti- pyretic	[24] [3]
Fruit	Chloroform, n- hexane and methanol	Anti- cancer property	[79]
Fruit	Solvent petroleum ether extract	Anthelmintic activity	[42]
Fruits	Ethanolic extract	Antiviral activity and antimicrobial activity	[83]
Leaves	Aqueous extract	Anti-diabetic property	[29]
Roots	Ethanolic extract	Hepatoprotective activity and cardiovascular activity	[25]
Leaf, stem, bark and fruits	Methanolic and aqueous extract	Anti-malarial activity	[7]

(44)

### 3. CONCLUSION

In essence, bael, woodapple, aonla, ber, and karonda represent a reservoir of natural resources, offering a diverse spectrum of nutraceutical benefits and therapeutic applications. Their extensive nutritional profiles and bioactive constituents, such as phenolics, flavonoids, and alkaloids, underscore their profound significance in preventive and holistic healthcare. As ongoing scientific investigations delve deeper into their latent potentials, incorporating these fruits into dietary and wellness regimens holds promise for cultivating robust health and vitality. Embracing and harnessing the nutraceutical and therapeutic attributes of these fruits can substantially contribute to the advancement of comprehensive health and well-being, both at the individual and societal levels.

### 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 writing or editing of manuscripts.

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### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

1. Alam MI, Gomes A. Snake venom neutralization by Indian medicinal plants (*Vitex negundo* and *Embllica officinalis*) root extracts. *Journal of Ethnopharmacology*. 2003;86(1):75-80.
2. Anila L, Vijayalakshmi N. Flavonoids from *Embllica officinalis* and *Mangifera indica*—effectiveness for dyslipidemia. *Journal of Ethnopharmacology*. 2002;79(1), 81-87.
3. Anupama N, Madhumitha G, Rajesh KS. Role of dried fruits of *Carissa carandas* as anti-inflammatory agents and the analysis of phytochemical constituents by GC-MS. *BioMed Research International*; 2014.
4. Arif M, Kamal M, Jawaid T, Khalid M, Saini KS, Kumar A, Ahmad M. *Carissa carandas* Linn. (Karonda): An exotic minor plant fruit with immense value in nutraceutical and pharmaceutical industries. *Asian J. Biomed. Pharm. Sci*. 2016;6(58):14-19.
5. Badam L, Bedekar S, Sonavane KB, Joshi SP. *In vitro* antiviral activity of bael (*Aegle marmelos* Corr) upon. *J. commun. Dis*. 2002;34(2):88.
6. Bagul V, Dhabekar S, Sansarode D, Dandekar S. Wood Apple (*Limonia acidissima* L.): A multipurpose herb in cosmetics. *Int. J. Sci. Dev. and Res*. 2019;4(7):172-181.
7. Bapna S, Ramaiya M, Chowdhary A. Antimalarial activity of *Carissa carandas* Linn. against *Plasmodium falciparum*. *Photon J. Microbiol*. 2013;12:246-250.
8. Bellah SF, Raju MIH, Billah SS, Rahman SE, Murshid GMM, Rahman MM. Evaluation of antibacterial and antidiarrhoeal activity of ethanolic extract of *Feronia limonia* Leaves. *The Pharma Innovation*. 2015;3(11, Part B):50.
9. Bhardwaj RL. Role of bael fruit juice in nutritional security of *Sirohi tribals*. *Benchmark Survey Report of Sirohi Tribals, Krishi Vigyan Kendra, AU, Jodhpur*. 2014;11-37.
10. Bhattacharjya D, Sadat A, Dam P, Buccini DF, Mondal R, Biswas T, Biswas K, Sarkar H, Bhuimali A, Kati A, Mandal AK. Current concepts and prospects of mulberry fruits for nutraceutical and medicinal benefits. *Current Opinion in Food Science*. 2021 Aug 1;40:121-35.
11. Chhetri S, Kundu S, Tamang A, Mahato S, Mahato A. The bael (*Aegle marmelos* L. Corr.): health benefits and its varietal wealth. *Environment and Ecology*. 2021;19(4A):1355-1361.
12. Dahiru D, Mamman DN, Wakawa HY. *Ziziphus mauritiana* fruit extract inhibits carbon tetrachloride-induced hepatotoxicity in male rats. *Pakistan Journal of Nutrition*. 2010;9(10): 990-993.
13. Das A. Ethno-medicines used by Santals & Paharias for treating skin diseases; 2021.
14. Dhakar A, Chorotiya P, Meena M, Singh C, Purvia RP, Adlakha MK. Pharmacological properties and phytochemical of *Limonia*

- acidissima*: A review. World J Pharm Res. 2019;8(10):637-45.
15. Diwan G, Sinha K, Lal N, Rangare NR. Tradition and medicinal value of Indian gooseberry: A review. Journal of Pharmacognosy and Phytochemistry. 2018;7(1):2326-2333.
  16. Dubey G, Shahu P, Shahu R. Role of plants in different religious ceremonies common to Bundelkhand region, Madhya Pradesh. Jour. Of Med. Arom. Plants Sci. 2001;23(11A):542-545.
  17. Duke JA. Handbook of biologically active phytochemicals and their activities. CRC Press, Inc; 1992.
  18. Ghosh S, Playford RJ. Bioactive natural compounds for the treatment of gastrointestinal disorders. Clinical science. 2003;104(6):547-556.
  19. Gupta R, Johri S, Saxena AM. Effect of ethanolic extract of *Feronia elephantum* Correa fruits on blood glucose levels in normal and streptozotocin-induced diabetic rats; 2009.
  20. Gurjar PS, Lal N, Gupta AK, Marboh ES. A review on medicinal values and commercial utility of bael. International Journal of Life-Sciences Scientific Research. 2015;1(1):5-7.
  21. Hansel R, Keller K, Rimpler H, Schneider G. Hager's hand buch der pharmazeutischen praxis, Springer-Verlag, Berlin. 1994;1:196.
  22. Haque N, Chowdhury SAR, Nutan MTH, Rahman GMS, Rahman KM, Rashid MA. Evaluation of antitumor activity of some medicinal plants of Bangladesh by potato disk bioassay. Fitoterapia. 2000;71(5):547-552.
  23. Hasmah SN, Bhatt A, Keng CL. Micropropagation of asam karanda (*Carissa carandas* Linn). Pertanika Journal of Tropical Agricultural Science. 2013;36(1).
  24. Hati M, Jena BK, Kar S, Nayak AK. Evaluation of anti-inflammatory and antipyretic activity of *Carissa carandas* L. leaf extract in rats. Int. J. Pharm. Chem. Bio. Sci. 2014;1:18-25.
  25. Hegde K, Joshi AB. Hepatoprotective effect of *Carissa carandas* Linn root extract against CCl<sub>4</sub> and paracetamol induced hepatic oxidative stress; 2009.
  26. Huang L, Ye W, Cai B, L, D, Liu J, Liu M. A preliminary study on the pharmacology of the compound prescription huangqin tang and its component drugs. Zhongguo Zhong yao za zhi= Zhongguo Zhongyao Zazhi= China Journal of Chinese Materia Medica. 1990;15(2):115-7.
  27. Jain M, Kapadia R, Jadeja RN, Thounaojam MC, Devkar RV, Mishra SH. Hepatoprotective activity of *Feronia limonia* root. Journal of Pharmacy and Pharmacology. 2012;64(6):888-896.
  28. Jarald EE, Joshi SB, Jain DC. Antidiabetic activity of extracts and fraction of *Zizyphus mauritiana*. Pharmaceutical Biology. 2009;47(4):328-334.
  29. Jigna P, Rathish N, Sumitra C. Preliminary screening of some folklore medicinal plants from western India for potential antimicrobial activity. Indian Journal of Pharmacology. 2005;37(6): 408-409.
  30. Kim HJ, Yokozawa T, Kim HY, Tohda C, Rao TP, Juneja LR. Influence of amla (*Embllica officinalis* Gaertn.) on hypercholesterolemia and lipid peroxidation in cholesterol-fed rats. Journal of nutritional science and vitaminology. 2005;51(6):413-418.
  31. Kour S, Bakshi P, Sharma A, Wali VK, Jasrotia A, Kumari S. Strategies on conservation, improvement and utilization of underutilized fruit crops. Int J Curr Microbiol App Sci. 2018;7(03):638-650.
  32. Kumar AS, Venkatesalu V, Kannathasan K, Chandrasekaran M. Chemical constituents and antibacterial activity of the leaf essential oil of *Feronia limonia*. Indian Journal of Microbiology. 2010;50:70-73.
  33. Kumar D, Pandey V, Nath V. Karonda (*Carissa congesta*) an underutilized fruit crop. Underutilized and Underexploited Horticulture Crops). 2007;313-325.
  34. Kumar V. Exploration of medicinal properties of fruits for health and nutritional security. Progressive Agriculture. 2011;11(conf):225-233.
  35. Lee SM, Min BS, Lee CG, Kim KS, Kho YH. Cytotoxic triterpenoids from the fruits of *Zizyphus jujuba*. Planta Medica. 2003;69(11):1051-1054.
  36. Lindsay EA, Berry Y, Jamie JF, Bremner JB. Antibacterial compounds from *Carissa lanceolata* R. Br. Phytochemistry. 2000;55(5):403-406.
  37. Liobikas J, Majiene D, Trumbeckaite S, Kursvietiene L, Masteikova R, Kopustinskiene DM, Bernatoniene J. Uncoupling and antioxidant effects of ursolic acid in isolated rat heart mitochondria. Journal of Natural Products. 2011;74(7):1640-1644.

38. Liu J. Pharmacology of oleanolic acid and ursolic acid. Journal of ethnopharmacology. 1995;49(2):57-68.
39. Maity P, Hansda D, Bandyopadhyay U, Mishra DK. Biological activities of crude extracts and chemical constituents of Bael, *Aegle marmelos* (L.) Corr; 2009.
40. Maurya RV, Kumar A. A Review on–pharmacological effect of *Carissa carandas* L; 2023.
41. Meena VS, Gora JS, Singh A, Ram C, Meena NK, Rouphael Y, Kumar P. Underutilized fruit crops of Indian arid and semi-arid regions: Importance, conservation and utilization strategies. Horticulturae. 2022;8(2):171.
42. Mishra CK, Sasmal D, Shrivastava B. An *In vitro* evaluation of the anthelmintic activity of unripe fruits extract of *Carissa carandas* Linn. Int J Drug Dev Res. 2012;4(4):393-7.
43. Moharib SA, Adly RS. Hypoglycemic and hepatoprotective activities of coriander (*Coriandrum sativum*) extract in streptozocin induced diabetic rats. Journal of Advances in Biology & Biotechnology. 2024;27(2):15–38. Available:https://doi.org/10.9734/jabb/2024/v27i2696
44. Muhammad A, Muhammad Q, Rafiq A. Effect of sea salt irrigation on plant growth, yield potential and some biochemical attributes of *Carissa carandas*. Pakistan Journal of Botany. 2016;48(3):853-859.
45. Pal R, Kulshreshtha DK, Rastogi RP. A new lignan from *Carissa carandas*. Phytochemistry. 1975;14(10):2302-2303.
46. Panda D, Panda S, Pramanik K, Mondal S. Karonda (*Carissa spp.*): an underutilized minor fruit crop with therapeutic and medicinal use. International Journal of Economic Plants. 2014;1(1):36-41.
47. Pareek OP, Suneel S. Genetic resources of under-exploited fruits. Advances in horticulture: fruit crops. 1993;1:189-225.
48. Park SN, Lim YK, Freire MO, Cho E, Jin D, Kook JK. Antimicrobial effect of linalool and  $\alpha$ -terpineol against periodontopathic and cariogenic bacteria. Anaerobe. 2012;18(3):369-372.
49. Parvez G, Sarker RK. Pharmacological potential of wood apple (*Limonia acidissima*): A Review. IJMFM and AP. 2021;7(2):40-47.
50. Pathak AK, Bhutani M, Nair AS, Ahn KS, Chakraborty A, Kadara H, Aggarwal BB. Ursolic acid inhibits STAT3 activation pathway leading to suppression of proliferation and chemosensitization of human multiple myeloma cells. Molecular Cancer Research. 2007;5(9): 943-955.
51. Phapale R, Thakur SM. Antioxidant activity and antimutagenic effect of phenolic compounds in *Feronia limonia* (L) swingle fruit. International Journal of Pharmacy and Pharmaceutical Sciences. 2010;2(4):68-73.
52. Pino JA, Marbot R, Vázquez C. Volatile flavor constituents of Karanda (*Carissa carandas* L.) fruit. Journal of Essential Oil Research. 2004;16(5):432-434.
53. Premkumar N. A study of phytochemical analysis and pharmacological activities of *Withania somnifera*. Asian Journal of Biochemistry, Genetics and Molecular Biology. 2023;15(2):24–37. Available:https://doi.org/10.9734/ajbgmb/2023/v15i2330
54. Priya EM, Gothandam KM, Karthikeyan S. Antidiabetic activity of *Feronia limonia* and *Artocarpus heterophyllus* in streptozotocin induced diabetic rats. Am. J. Food Technol. 2012;7:43-49.
55. Rahman S, Parvin R. Therapeutic potential of *Aegle marmelos* (L.)-An overview. Asian Pacific Journal of Tropical Disease. 2014;4(1):71-77.
56. Rakhunde PB, Saher S, Ali SA. Neuroprotective effect of *Feronia limonia* on ischemia reperfusion induced brain injury in rats. Indian Journal of Pharmacology. 2014;46(6):617.
57. Ram MS, Neetu D, Yogesh B, Anju B, Dipti P, Pauline T, Selvamurthy W. Cytoprotective and immunomodulating properties of Amla (*Emblica officinalis*) on lymphocytes: An *In vitro* study. Journal of Ethnopharmacology. 2002;81(1):5-10.
58. Rastogi RP, Mehrotra BN. In compendium of Indian medicinal plants, CDRI., Lucknow & Publications & Information Directorate, New Delhi. 1998;5:18.
59. Reisch J, Hussain RA, Krebs B, Dartmann M. Natural product chemistry, part 100: The structure of carissone, C 15 H 24 O 2. Monatshefte für Chemie/Chemical Monthly. 1990;121(11):941-944.
60. Saha R, Hossain L, Bose U, Rahman AA. Neuropharmacological and diuretic activities of *Carissa carandas* linn. leaf. Pharmacologyonline. 2010;(2):320-327.
61. Saima Y, Das AK, Sarkar KK, Sen Sr AK, Sur P. An antitumor pectic polysaccharide from *Feronia limonia*. International Journal



- of Biological Macromolecules. 2000;27(5):333-335.
62. Senthilkumar KL, Kumawat BK, Rajkumar M. Antidiarrhoeal activity of bark extracts of *Limonia acidissima* Linn. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2010;1(4):550-553.
  63. Sharma B, Patidar J, Pachauri DR, Tripathy S. Contribution of minor fruits crops to household nutritional security and health for rural population. International Journal of Chemical Studies. 2019;7(3):2942-2949.
  64. Sharma N. Aonla (*Emblica officinalis*): A Wonderful Berry with Therapeutic Effects; 2022.
  65. Sharma N, Kumar M, Kumari N, Rais N, Pundir A, Anitha T, Mekhemar M. Beneath the rind: A review on the remarkable health benefits and applications of the wood apple fruit. Heliyon; 2024.
  66. Sharma PC, Bhatia V, Bansal N, Sharma A. A review on Bael tree; 2007.
  67. Shishodia S, Majumdar S, Banerjee S, Aggarwal BB. Ursolic acid inhibits nuclear factor-κB activation induced by carcinogenic agents through suppression of IκBα kinase and p65 phosphorylation: Correlation with down-regulation of cyclooxygenase 2, matrix metalloproteinase 9, and cyclin D1. Cancer Research. 2003;63(15):4375-4383.
  68. Shoba FG, Thomas M. Study of antidiarrhoeal activity of four medicinal plants in castor-oil induced diarrhoea. Journal of Ethnopharmacology. 2001;76(1):73-76.
  69. Singh AK, Pal R, Abrol G, Punetha S, Sharma P, Pandey AK. Nutritional and medicinal value of underutilized fruits. Acta Scientific Agriculture. 2019;3(1):16-22.
  70. Singh B, Rastogi RP. The structure of carindone. Phytochemistry. 1972;11(5):1797-1801.
  71. Singh B, Kumar S, Singh R. *Aegle marmelos* (L.) Correa: A potential fruit for health and pharmaceuticals. Food Science & Nutrition. 2020;8(3):1400-1410.
  72. Singh DP, Govindarajan R, Rawat AKS. High-performance liquid chromatography as a tool for the chemical standardisation of Triphala—an Ayurvedic formulation. Phytochemical Analysis: An International Journal of Plant Chemical and Biochemical Techniques. 2008;19(2):164-168.
  73. Singh HB, Arora RK. Wild edible plants of India. Wild edible plants of India; 1978.
  74. Singh J, Nigam R. Underutilized Arid Fruits in India: A Review; 2022.
  75. Singh S, Singh AK, Apparao VV, Bhargava R. Thar Kamal: A new karonda variety. Indian Horticulture. 2013;58(4):9-10.
  76. Sonawane S, Arya SS. Antioxidant activity of jambhul, wood apple, ambadi and ambat chukka: An indigenous lesser known fruits and vegetables of India. Adv J Food Sci Technol. 2013;5(3):270-275.
  77. Sri Kumar R, Parthasarathy NJ, Shankar EM, Manikandan S, Vijayakumar R, Thangaraj R, Rao UA. Evaluation of the growth inhibitory activities of Triphala against common bacterial isolates from HIV infected patients. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives 2007;21(5): 476-480.
  78. Su X, Chen Z, Jiao B, Huang Q, Li W. Studies on anti-allergic activity of common foodstuffs in China and their constituents. Journal of Southwest Agricultural University. 2000;21(1):77-80.
  79. Sulaiman SF, Wong ST, Ooi KL, Yusof SR, Muhammad T, Sifzizul T. Anticancer study of *Carissa carandas* extracts. Project Report. USM. 2008;1-6.
  80. Suryanarayana P, Saraswat M, Petrash JM, Reddy GB. *Emblica officinalis* and its enriched tannoids delay streptozotocin-induced diabetic cataract in rats; 2007.
  81. Takase H, Yamamoto K, Hirano H, Saito Y, Yamashita A. Pharmacological profile of gastric mucosal protection by marmin and nobiletin from a traditional herbal medicine, *Aurantii fructus immaturus*. The Japanese Journal of Pharmacology. 1994;66(1):139-147.
  82. Tanvir EM, Afroz R, Karim N, Mottalib MA, Hossain MI, Islam MA, Khalil MI. Antioxidant and antibacterial activities of methanolic extract of BAU K ul (*Ziziphus mauritiana*), an Improved Variety of Fruit from Bangladesh. Journal of Food Biochemistry. 2015;39(2):139-147.
  83. Taylor RS. Medicinal plants of Nepal: Ethnomedicine, pharmacology, and phytochemistry (Doctoral dissertation, University of British Columbia); 1996.
  84. Thakur N, Chugh V, Dwivedi S. Wood apple: An underutilized miracle fruit of India. The Pharma Innovation Journal. 2020;9:198-202.
  85. Troup RS. The silviculture of Indian trees (Vol. 1). Clarendon Press; 1921.

86. Vasudevan M, Parle M. Effect of Anwala Churna (*Emblica officinalis* G AERTN.): An Ayurvedic preparation on memory deficit rats. *Yakugaku Zasshi*. 2007;127 (10): 1701-1707.
87. Venthodika A, Chhikara N, Mann S, Garg MK, Sofi SA, Panghal A. Bioactive compounds of *Aegle marmelos* L., medicinal values and its food applications: A critical review. *Phytotherapy Research*. 2021;35(4): 1887-1907.
88. Vidhya R, Narain A. Development of preserved products using under exploited fruit, wood apple (*Limonia acidissima*). *American Journal of Food Technology*. 2011;6(4):279-288.
89. Wakchoure SM, Raut PG, Jadhav SN, Kinikar D, Dhangar H. Multipotential traditional plant wood apple (*limonia acidissima*): A; 2011.
90. Wiart C. Medicinal plants of the Asia-Pacific: drugs for the future?. *World Scientific*; 2006.

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