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REVIEW ARTICLE

Nutritional and medicinal values of *Mangifera indica* L. fruit

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ABSTRACT

Mangifera indica L. (Mango, Anacardiaceae) is a popular tropical evergreen tree known for its nutritional and medicinal values. It is native to India and Southeast Asia and is known as the "king of fruits" in India and the Philippines. It is considered important in Ayurveda and other systems of medicine. Mango fruit is unique in its taste, colour, aroma, and nutritional qualities. Mangoes are a rich source of polyphenols (Mangiferin, Gallotannins, Quercetin, Isoquercetin, Ellagic acid, Glucogallin, Kaempferol, Catechins, Tannins, and the unique Xanthonoid), phenolic acids (Hydroxybenzoic acids- Gallic, Vanillic, Syringic, Protocatechuic, and *p*-Hydroxybenzoic acids, Hydroxycinnamic acid derivatives-*p*-Coumaric, Chlorogenic, Ferulic, and Caffeic acids), flavonoids (β-carotene, α-carotene, β-cryptoxanthin, and Lutein), Vitamin A, Vitamin-B6 (pyridoxine), Vitamin-C, Vitamin-E, Carbohydrates, Amino acids, Organic acids, micronutrients (Potassium, Copper), fats (Omega-3 and 6 polyunsaturated fatty acids), dietary fibre and certain volatile compounds. About 25 different types of carotenoids have been isolated from the fruit pulp, which contributes to the colour of the fruit. Phytochemical and nutrient content may vary depending on the cultivar. Mangoes possess potential medicinal properties such as antioxidant, gastro-protective, anti-inflammatory, analgesic, immunomodulatory, anti-microbial, and many more. Mango fruit is an abundant source of all essential nutrients and phytochemicals; it could be ultilized as a nutritional supplement in the prevention and cure of several diseases. A comprehensive report on the nutritional and medicinal properties of fruit is presented below.

Keywords: mango; fruit; polyphenols; phenolics; flavonoids; carbohydrates; proteins; fats vitamins; minerals; medicinal properties

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1. Introduction

Mangiferaindica L. (Mango), "the king of fruits", is an evergreen tropical fruit tree comprising about 69 species belonging to the family Anacardiaceae. The tree is indigenous to India and Southeast Asia[1]. It is the national fruit of India and the Philippines and the national tree of Bangladesh[2]. It is a common fruit tree cultivated on about 3.7 million hectares worldwide. More than 1000 varieties of mangoes are commercially cultivated in 87 countries. For hundreds of centuries, mangoes have been grown in the Himalayan region, Burma, and Bangladesh. For thousands of years, many cultivars have been vegetatively propagated in India[3]. Birbal Sahni Institute of Palaeobotany, Lucknow, has excavated 60 million-year-old fossilized mango leaf compression in Palaeocene sediments in Damalgiri, Meghalaya, and named it *Eomangiferophyllum damalgiriensis*[4]. Extensive anatomical and morphological studies on the present genus and the fossilized material have revealed that North-East India was the centre of the origin of mangoes. It spread to Southeast Asia later. Today, they are extensively grown in Central America[5], Africa[6], Australia[7],

and Europe[8]. The main mango-producing countries in the world are India, Pakistan, Mexico, Brazil, Haiti, the Philippines, and Bangladesh.

Mango is a delicious fruit and is hence called "food for gods". It is rich in prebiotic dietary fibre, vitamins A and C, minerals, and polyphenolic flavonoid antioxidant compounds. According to Habib et al.[9] and Lauricella et al.[10], mangoes provide 64–86 calories of energy. It contains sugar, protein, fats, and other nutrients. Mangoes are eaten fresh as a dessert and processed as pickles, jams, jellies, sauces, nectar, juices, cereal flakes, and chips[11]. Generally, mangoes are edible at all stages of development, from the tiny set fruit to the mature ones. The nutritional value of mangoes depends on the variety and the developmental stage[12]. In traditional systems of healing Mango, fruits are used to cure sunstroke, ophthalmia, eruption, intestinal disorder, infertility, and night blindness. The oil used in eczema[13–15]. Seed kernel is used in hemorrhages and bleeding hemorrhoids. Seed can be applied to ulcers, bruises, leucorrhoea, and burns to treat diabetes, heartburn and vomiting, asthmatic cough, helminthiasis, chronic diarrhea, dysentery, menorrhagia, and hemoptysis[16]. The entire fruit has several phytochemical and nutritive constituents. Consumption of mango fruit along with a balanced diet can enhance the health status of an individual. The nutritional and medicinal properties of fruit peel, pulp, and seed are discussed below.

2. Description of the fruit

A single mature mango tree can produce as many as 2000 to 2500 ripe fruits. Mango fruit is a drupe. The length of the fruit ranges from 2.5 cm to more than 30 cm. The pericarp, or peel, is waxy, smooth, thick, and aromatic. When unripe, the peel is light green to dark green, and as it ripens, the colour changes from yellow to reddish pink (**Figure 1**).

Figure 1. Entire fruit of Alphonsa variety of mango.

The aroma of the fruit ranges from a "turpentine" odour to a pleasant fragrance, depending on the cultivar. The shape of the mango may be oblong or sub-reniform. The mesocarp is the fleshy, juicy, sweet, and edible portion of the fruit. The pulp is yellow to dark orange in colour[17]. The endocarp is hard, woody, stony, fibrous, flattened, and longitudinally ribbed in nature (**Figure 2**). It is pale yellowish-white in colour and contains a solitary seed. The seed is generally monoembryonic or polyembryonic.

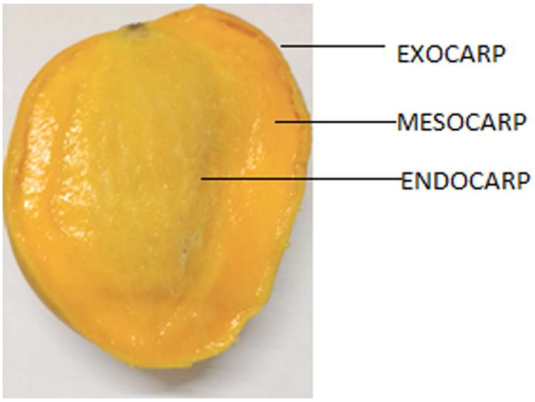

Figure 2. Longitudinal section of the entire Alphonsa mango showing the various parts.

3. Phytochemicals in the fruit

The nutritional and medicinal values of the fruit are mainly due to the phytochemical constituents. These phytochemicals also contribute to the taste, aroma, and flavour of the fruit[18]. The fruits also yield a resin that contains mangiferin, mangiferic acid, resinol, and maniferol[19,20]. The fruit is economically and nutritionally important and, hence, recommended by health organizations.

3.1. Phytochemicals in pulp

The edible part of mango contains an array of compounds such as polyphenols, phytosterols, isoflavones, and carotene. β-carotene is abundantly present in the pulp and is responsible for its attractive colour. β-carotene, a potent antioxidant, has several health benefits. The carotene content in the fruit is approximately 10.7 mg per 100 g of edible portion. Dietary antioxidants, such as phenolic compounds, are present. However, the concentration depends on the species and variety[21]. Major phenolic compounds such as chlorogenic, gallic, protocatechuic, and vanillic acids were reported by Palafox-Carlos et al.[18]. Khoo and Ismail[22] have reported the presence of isoflavones such as daidzein and genistein. These isoflavones act as phytoestrogens. Recently, 34 phenolic acid derivatives have been reported. Rosmarinic acid was detected in the pulp at different stages of ripening[23]. Flavonoids (quercetin, kaempferol, catechins, anthocyanins, rhamnetin, and tannic acid) and the class of xanthones, mangiferin, are reported in mango[24,25]. Fisetin, isorhamnetin, kaempferol, and myricetin are present at minimum levels[26–28].

Mangiferin, a xanthone compound (a natural polyphenolic antioxidant), exhibits great antioxidant properties[29]. The maximum mangiferin content of mango pulp is 4 mg per 100 g. Further, lupeol, a triterpene, is also found in mango. The lupeol content in mango pulp is approximately 0.181 mg per 100 g of edible portion. An unusual carboxylic acid, cis-9, cis-15-octadecadienoic acid, was reported from the pulp of mango.

3.2. Phytochemicals present in *Mangifera indica* peel

Mango peel is a source of valuable constituents[30–32] such as polyphenols, phenolic compounds such as vanillic acid, gallic acid, ferulic acid, coumaric acid, chlorogenic acid[33] pyrogallic acid, syringic gallotannins catechin, epicatechin, methyl gallate ester, methyl gallate[34], galloyl glucose, theogallin, protocatechuic, mangiferin, rutin[35], carotenoids, vitamins E and C. Schieber et al.[29] reported the presence of flavonoids, quercetin, and kaempferol. Chlorogenic acid (82%) and vanillin acid (17%), according to Benitez et al.[5], were reported to have antioxidant activity[18]. A recent comparative study shows that the peels contained significant polyphenols and had the highest antioxidant activity when compared to the pulp[36,37]. Moreover, mango peel is a good source of dietary fibre, proteins, and carbohydrates[38,39]. Hence, it finds its application in the food and nutraceutical Industries[40]. Mango peel flour is used in bakery products[41]. Unsaturated fatty acids such as oleic acid, linoleic acid, and ethyl linoleate are also present in the peels[42].

3.3. Phytochemicals present in *Mangifera indica* seed

The mango seeds are rich in fatty acids, sterols, and triterpenoids. Long-chain hydrocarbons and fatty acids include linoleic, octadecanoic acid, linolenic, eicosanoic acid, monounsaturated fatty acid, hexadecanoic acid, and arachidonic acid. Sterols such as sitosterol, campesterol, and stigmasterol, α-pinene, myrcene, β-pinene, and limonene are the chief triterpenes and triterpenoids. The seeds of mango fruit are also considered promising sources of polyphenols[28]. Polyphenols and phenolic acids include ascorbic acid, mangiferin, quercetin, and gallic acid[43].

4. Nutrients in *Mangifera indica* fruit

According to Masibo and He[28], the fruit of mango is unique because all the parts—peel, pulp, and kernel—are nutritionally significant. Mango fruit has a high amount of water (approximately 86%), carbohydrates (25%), proteins (5.11%), and lipids (2.7%). The seed kernel is rich in carbohydrates, protein, fats, vitamins, and minerals. The quantity of nutrients in the fruit and kernel depends on the cultivar, climatic conditions, ripening and harvesting times, and the type of soil. It is estimated that only 3% of the pulp has important nutrients when compared to the seed kernel, which has 20–50 times more nutrients than the pulp (**Figure 3**).

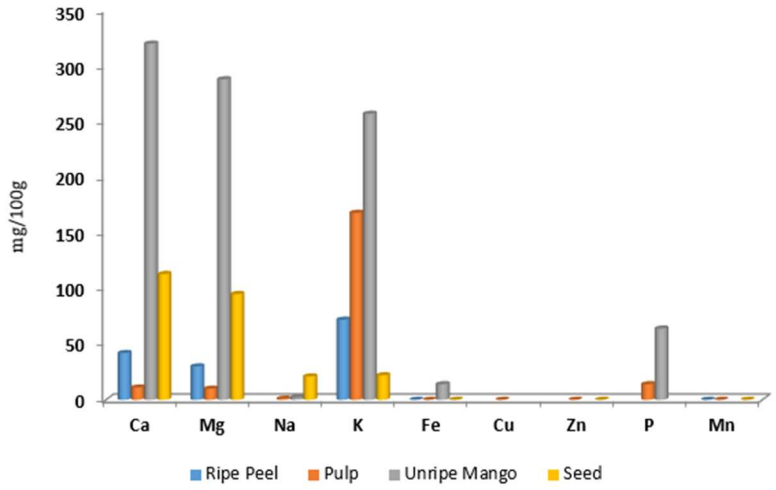

Figure 3. Nutrient's composition in *Mangifera indica* fruit.
* Adapted from Patel and Kheni[44], Shobana and Rajalakshmi[45], Tokas et al.[46] and Yatnatti et al.[47].

4.1. Dietary fibre

The fruit pulp is very nutritious and easily digestible due to its rich source of dietary fibres[48]. The dietary fibre in the fruit regulates glucose and lipid levels in the blood[49]. Barbosa Gámez et al.[50] reported a higher total dietary fibre content in ripened fruits than in unripe ones.

4.2. Vitamins and minerals

Vitamins and minerals contribute a major part of the nutrient components of fruits; these compounds are essential for various biochemical and physiological processes in the body. Vitamins are organic compounds that are essential nutrients for normal cell functions, growth, and development in humans. Vitamins help in the breakdown and assimilation of proteins, carbohydrates, and fats. Most vitamins—A, C, D, E, K, B_1, B_2, B_3, B_5, B_6, B_7, B_9, and B_{12} (except Vitamin D)—cannot be synthesized in our body and have to be acquired only through food intake. Major minerals required in larger quantities include phosphorus, magnesium, potassium, sodium, calcium, and chloride. In addition, trace elements such as iron, fluoride, iodine, cobalt, chromium, copper, manganese, molybdenum, selenium, and zinc are required for the normal functioning of the body[51].

The mango fruit is a good source of calcium, magnesium, potassium, zinc, and phosphorus[52]. The unripe fruit is rich in calcium, magnesium, potassium, and phosphorus (**Figure 4**).

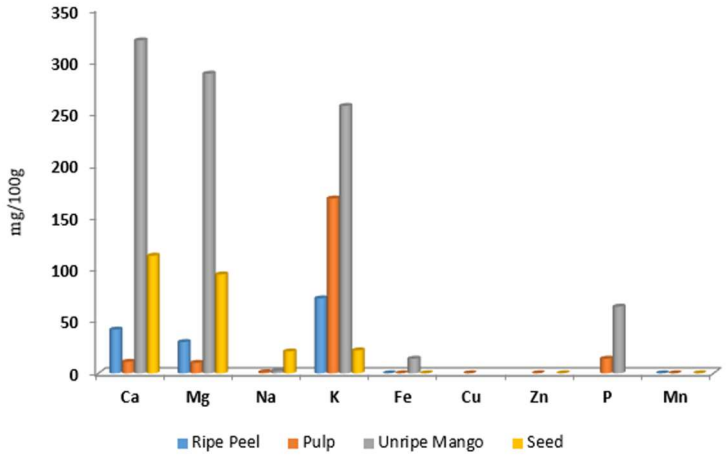

Figure 4. Mineral composition of *Mangifera indica* fruit.
* Adapted from Patel and Kheni[44], Shobana and Rajalakshmi[45], Tokas et al.[46], Yatnatti et al.[47],and Fowomola[53].

The mango varieties vary greatly in vitamin C content[51]. Unripe mango is rich in all vitamins except vitamin B_{12} (**Table 1**). On the other hand, the seed kernel contains vitamins A, K, E, C, and B_{12}. It is also rich in minerals such as potassium, calcium, iron, sodium, phosphorous, magnesium, zinc, and manganese[54].

Table 1. Vitamin composition of *Mangiferaindica* fruit*.

Vitamins mg/100g	Ripe peel	Pulp	Unripe mango	Seed
Vitamin A	12	725	846	10
Vitamin B_2	-	0.038	0.1	0.03
Vitamin B_3	-	0.669	-	-
Vitamin B_5	-	0.160	-	-
Vitamin B_1	-	0.028	0.1	0.08
Vitamin B_6	-	0.119	0.1	0.19
Vitamin K	-	0.042	0.0042	0.59
Vitamin C	52	36	46	0.56
Vitamin E	-	1.12	1.8	1.3
Foliate	-	0.0043	0.014	-
Vitamin B_{12}	-	-	-	0.12

*Adapted from Patel and Kheni[44], Shobana and Rajalakshmi[45], Tokas et al.[46], Yatnatti et al.[47] and Fowomola[53].

4.3. Proteins and amino acids

Mangoes, like any other fruit, contain a low protein content. The amino acid composition also varies among cultivars and maturation levels[55]. The amino acids Alanine, Arginine, Glycine, Leucine, Isoleucine, and Serine have been detected in considerable amounts in the ripened mangoes, while all other amino acids are present in trace quantities only[56]. The amino acids that cannot be synthesized in humans are phenylalanine, tryptophan, methionine, valine, lysine, threonine, leucine, isoleucine, and histidine. Usually, seeds are rich in protein. The mango kernel has approximately 20 times more protein than the pulp. According to Fowomola[53], except for tryptophan, all eight other essential amino acids are present in the kernel (**Figure 5**). Hence, mango seeds are considered an excellent supplementary food.

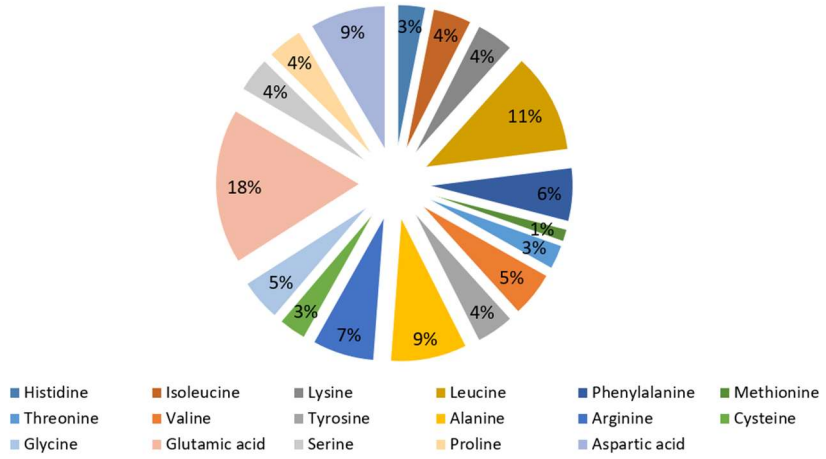

Figure 5. Essential and non-essential amino acid composition of *Mangifera indica* seed (g/100g seed).
* Adapted from Fowomola[53].

4.4. Carbohydrates

The ripened fruit contains glucose, fructose, sucrose, starch, and pectin. Sucrose is the major sugar in the pulp[57]. The mango pulp has approximately 17% carbohydrate. However, the seeds contain a higher reserve of carbohydrates than the unripe mango. During ripening, starch gets hydrolysed into sugars, and hence, at the ripened stage, the pulp is rich in fructose and glucose[58]. However, the composition of the fruit depends on the cultivar[59], climatic conditions, ripeness at harvest[60], and post-harvest storage of the fruits.

4.5. Lipids

The lipid content of the unripe mango peel and seeds is considered to be higher than that of cocoa butter. The ripe mango has a lower fat content. The major fatty acids present in the kernel are oleic, linoleic acid, palmitic, stearic, arachidic, lignoceric, and behenic acids, which are present in lower concentrations[61]. Thus, mango seed fats can be an alternative to cocoa butter. Triglycerides are a greater component of the pulp than monoglycerides and diglycerides. During ripening, the levels of unsaturated fatty acids and omega-6 and omega-3 fatty acids seem to increase, and hence mango is a rich source of essential fatty acids[62].

4.6. Organic acids

Organic acid is essential for flavour constituents that are responsible for fruit quality, organoleptic properties, and the acidity of the fruit[63]. Certain varieties are reported to contain α-ketoglutaric, ascorbic, oxalic, and tartaric acids at lower concentrations, while succinic and malic acids were also detected at higher concentrations in certain varieties[59]. However, citric acid and malic acid are the major organic acids found in the pulp[56].

5. Ethno medicinal uses of *Magnifera indica*

According to Ayurveda, Vata, Pitta, and Kapha Doshas are vital energies that govern, regulate, and control the physical and mental well-being of a human. It is used to treat vitiated conditions of the Vata and Pitta.

Ripe mango fruit is a restorative tonic and is used for heat stroke. The fruit is sweet, refrigerant, cardiotonic, haemostatic, aphrodisiac, emollient, and laxative. Anorexia, dyspepsia, uterine, haemorrhages; emaciation, and anemia are also treated with the fruit. The unripe fruits are acidic, acrid, refrigerant, antiscorbutic, digestive, and carminative. The seeds are refrigerant, sweet, astringent, and acrid. They are used in treating cough, asthma, heart problems, ulcers, bruises, leucorrhoea, menorrhagia, diabetes, intestinal worms, constipation, haemorrhages, haemorrhoids, haemostatic, dysentery, chronic diarrhea, vomiting, and uterine

tonics. It is also used for liver disorders, tooth diseases, and as an antidote for poisonous scorpion and honeybee stings[13,14].

6. Medicinal properties of *Mangifera indica*

The polyphenols present in mangoes exert health benefits[64]. Furthermore, 25 diverse carotenoids have been identified that contribute to the colour and antioxidant properties of the fruit. The other antioxidant compounds are flavonoids (catechins, quercetin, kaempferol, rhamnetin, anthocyanins, and tannic acid) and xanthones like mangiferin[26].

6.1. Anti-oxidant

The mango peel is reported to possess antioxidant activity[65] which may be because of the phenolic content that confers the activity. Reactive oxygen species have a strong oxidizing effect that induces damage and brings about changes in the structure of proteins, lipids, and DNA. The antioxidants in the mango peel seem to scavenge the various harmful free radicals[42]. Other studies proved that it also acted as an iron chelator and offered protection against iron-induced oxidative damage.

6.2. Antiviral activity

Mangiferin in the fruit is reported to have antiviral activity against *Herpes simplex* virus type 2. Mangiferin inhibits the late replication of HSV-2 but does not directly inhibit it. However, HSV-1 replication inhibits and antagonizes the effects of HIV[66,67].

6.3. Antimicrobial activity

Mango extracts are reported to exhibit antibacterial and antifungal activity. The extracts were effective against gram-positive and gram-negative bacteria and *Candida albicans*[68]. Gallotanins and mangiferins are responsible for their activity[69]. *Alternaria alternata* was inhibited by aqueous, ethanol, and methanolic extracts of mango[70]. A recent study shows that the mango peel extracts, both aqueous and ethanolic, had significant antibacterial and antifungal activity against *Escherichia coli, Staphylococcus aureus*, *Bacillus cereus*, *Pseudomonas aerogenes,* and *Candida albicans*[71].

6.4. Antidiarrhoeal activity

The anti-diarrhoeal activity of seed extracts (methanol and aqueous) was studied in diarrhea-induced mice. Under experimental conditions, castor oil and magnesium sulphate were used as diarrhoeal agents. The methanolic extract had significant antidiarrhoeal activity. The kernel aqueous extract also exhibits anti-diarrheal activity[72,73].

6.5. Anti-inflammatory action

The phytochemicals present in mango have a significant anti-inflammatory action on pathological disorders[74,75]. Inflammatory bowel diseases are associated with the risk of colon and rectal cancers[76]. Mango extracts exert an anti-inflammatory action in experimental murine models of ulcerative colitis[77]. The mango mesocarp extract, rich in polyphenols, reduced the inflammatory response in colitis-induced mice[78]. An ethanolic extract of the seed kernel exhibited significant anti-inflammatory activity in acute, subacute, and chronic cases of inflammation.

6.6. Anti-diabetic effect

Phytochemicals in mangoes have an anti-diabetic effect. Diabetes mellitus is a metabolic disorder associated with hyperglycemia. Mango mesocarp extracts produced a significant hypoglycemic effect in streptozotocin (STZ)-induced diabetic rats[79,80]. Furthermore, Gondi et al.[81] showed that the administration

of different doses of exocarp extracts to diabetic rats resulted in a significant decline in blood glucose levels. The anti-diabetic effect of exocarp extracts was due to the inhibition of α-amylase and α-glucosidase[82].

6.7. Anticancer activity

An ethanolic extract of mango exocarp induced apoptosis in human cervix adenocarcinoma HeLa cells[83]. This activity may be due to quercetin-3-*O*-arabinopyranoside, mangiferingallate, quercetin 3-*O*-galactoside, isomangiferin gallate, and mangiferin present in the exocarp. The aqueous extract of mango mesocarp exerted antitumor activity in human colon adenocarcinoma cell lines and colorectal cancer in rodents[84]. Abdullah et al.[85] reported that an ethanolic extract of mango kernel induced cell death in both oestrogen-positive and oestrogen-negative breast cancer cell lines. Urushiol in the fruit peel may induce an allergic reaction[86]. Percival et al.[87] found that whole mango juice exerted anticancer activity by inhibiting the cell cycle in the G0/G1 phase. Mangiferin may interfere with the assembly or functioning of microtubules[88,89]. The other possible mechanisms of mangiferin are inhibition of telomerase[29] and an increase in cellular apoptosis. Kim et al.[83] reported the anti-proliferative activity of mango peels and pulp.

6.8. Anti-hemorrhagic and anti-dermonecrotic activity

The seed kernel ethanolic extract of mango exhibited an inhibitory effect on the caseinolytic and fibrinogenolytic activities of Viper and Cobra venom. The molecular docking studies revealed that mangiferin bound to the snake venom metalloproteinases and inhibited the venom enzymatic activity and tissue necrosis[90].

6.9. Hepatoprotective activity

Hepatoprotective activity was found in the ethanolic extracts of seed kernels[91]. Hepatoprotective activity was evaluated against liver injury in rats induced by carbon tetrachloride (CCl_4). Three polyphenolic principles, 1, 2, 3, 4, 6-penta-O-galloyl-β-D-glucopyranose (PGG), methyl gallate (MG), and gallic acid (GA), caused the hepatoprotective activity.

7. Conclusion

Mango fruit peel, pulp, and seed contain essential amino acids, proteins, vitamins, carbohydrates, fatty acids, dietary fibres, carotenoids, and phenolic compounds that contribute to gastrointestinal health. Mango peels are rich in antioxidants and hence possess free radical scavenging activity, which could prevent cancer. The fruit has anti-inflammatory action, which can prevent inflammatory bowel diseases. The seeds are reported to contain hepatoprotective action. Mangoes are rich in health-benefit constituents and are rightly called the "king of fruits". Regular consumption of mangoes, either in an unripe or ripened state, can prevent or cure several health-related diseases, and hence it could be utilized as a supplementary food in nutraceuticals. Further research on the various phytochemicals and their pharmacological activity will shed more light on their significance in human health.

Conflict of interest

The authors declare that there is no conflict of interest.

References

1. Mukherjee SK. The mango—Its botany, cultivation, uses and future improvement, especially as observed in India. *Economic Botany* 1953; 7(2): 130–162. doi: 10.1007/BF02863059
2. Usman M, Fatima B, Jaskani MJ. Breeding in Mango. *International Journal of Agriculture & Biology* 2001; 3(4): 522–526.
3. Deshpande DJ. *A Handbook of Herbal Remedies*. Agrobias; 2011.
4. Mehrotra RC, Dilcher DL, Awasthi N. A palaeocene mangifera-like leaf fossil from India. *Phytomorphology* 1998; 48(1): 91–100.

5. Benitez Blancas FJ, Mercado-Mercado G, Quirós-Sauceda AE, et al. Bioaccessibility of polyphenols associated with dietary fiber and in vitro kinetics release of polyphenols in Mexican 'Ataulfo' mango (*Mangifera indica* L.) by-products. *Food & Function* 2015; 6(3): 859–868. doi: 10.1039/C4FO00982G
6. Khakimov B, Mongi RJ, Sørensen KM, et al. A comprehensive and comparative GC-MS metabolomics study of non-volatiles in Tanzanian grown mango, pineapple, jackfruit, baobab and tamarind fruits. *Food Chemistry* 2016; 213: 691–699. doi: 10.1016/j.foodchem.2016.07.005
7. San AT, Joyce DC, Hofman PJ, et al. Stable isotope dilution assay (SIDA) and HS-SPME-GCMS quantification of key aroma volatiles for fruit and sap of Australian mango cultivars. *Food Chemistry* 2017; 221: 613–619. doi: 10.1016/j.foodchem.2016.11.130
8. Rodríguez Pleguezuelo CR, Durán Zuazo VH, Muriel Fernández JL, Franco Tarifa D. Physico-chemical quality parameters of mango (*Mangifera indica* L.) fruits grown in a Mediterranean subtropical climate (SE Spain). *Journal of Agricultural Science and Technology* 2012; 14(2): 365–374.
9. Rathore HA, Masud T, Sammi S, Soomro AH. Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety dosehari. *Pakistan Journal of Nutrition* 2007; 6(2): 143–148.
10. Lauricella M, Emanuele S, Calvaruso G, et al. Multifaceted health benefits of *Mangifera indica* L. (Mango): The inestimable value of orchards recently planted in Sicilian rural areas. *Nutrients* 2017; 9(5): 525. doi: 10.3390/nu9050525
11. Hamdard MS, Rafique MR, Farroq U. Physico-chemical characteristics of various mango, *Mangifera indica* L. varities. *Journal of Agricultural Research* 2004; 42(2): 191–199.
12. Leghari MH, Sheikh SA, Memon N. Quality attributes of immature fruit of different mango varieties. *Journal of Basic & Applied Sciences* 2013; 9: 52–56.
13. Ainslie W. *Materia Medica of Hindustan*. Neeraj Publishing House; 1813.
14. Achyrya B. *Ayurvedic Jadi Buti Rahashya*. Divya Prakashana; 2008.
15. Government of India. The ayurvedic pharmacopoeia of India. Available online: http://www.ayurveda.hu/api/API-Vol-2.pdf (accessed on 2 November 2023).
16. Parvez GMM. Pharmacological activities of mango (*Mangifera Indica*): A review. *Journal of Pharmacognosy and Phytochemistry* 2016; 5(3): 1–7.
17. Shah KA, Patel MB, Patel RJ, Parmar PK. Mangifera indica (mango). *Pharmacognosy Reviews* 2010; 4(7): 42–48. doi: 10.4103/0973-7847.65325
18. Palafox-Carlos H, Yahia EM, González-Aguilar GA. Identification and quantification of major phenolic compounds from mango (*Mangifera indica*, cv. Ataulfo) fruit by HPLC–DAD–MS/MS-ESI and their individual contribution to the antioxidant activity during ripening. *Food Chemistry* 2012; 135(1): 105–111. doi: 10.1016/j.foodchem.2012.04.103
19. Ghuniyal J. Ethanomedical, chemical, pharmacological, toxicological properties of mangiferaindica: A review. *International Journal of Pharma Research & Review* 2015; 4(10): 51–64.
20. Siddiq M, Akhtar S, Siddiq R. Mango processing, products and nutrition. In: Siddiq M (editor). *Tropical and Subtropical Fruits: Postharvest physiology, Processing and Packaging*. John Wiley & Sons; 2012. pp. 277–297. doi: 10.1002/9781118324097
21. Mirfat AHS, Salma I, Razali M. Natural antioxidant properties of selected wild *Mangifera* species in Malaysia. *Journal of Tropical Agriculture and Food Science* 2016; 44(1): 63–72.
22. Khoo HE, Ismail A. Determination of daidzein and genistein contents in *Mangifera* fruit. *Malaysian Journal of Nutrition* 2008; 14(2): 189–198.
23. Hu K, Dars AG, Liu Q, et al. Phytochemical profiling of the ripening of Chinese mango (*Mangifera indica* L.) cultivars by real-time monitoring using UPLC-ESI-QTOF-MS and its potential benefits as prebiotic ingredients. *Food Chemistry* 2018; 256: 171–180. doi: 10.1016/j.foodchem.2018.02.014
24. Claudine M, Augustin S, Christine M, et al. Polyphenols: Food sources and bioavailability. *The American Journal of Clinical Nutrition* 2004; 79(5): 727–747. doi: 10.1093/ajcn/79.5.727
25. Masibo M, He Q. Major mango polyphenols and their potential significance to human health. *Comprehensive Reviews in Food Science and Food Safety* 2008; 7(4): 309–319. doi: 10.1111/j.1541-4337.2008.00047.x
26. Berardini N, Fezer R, Conrad J, et al. Screening of mango (*Mangifera indica* L.) cultivars for their contents of flavonol *O*- and xanthone *C*-glycosides, anthocyanins, and pectin. *Journal of Agricultural and Food Chemistry* 2005; 53(5): 1563–1570. doi: 10.1021/jf0484069
27. Ribeiro SMR, Barbosa LCA, Queiroz JH, et al. Phenolic compounds and antioxidant capacity of Brazilian mango (*Mangifera indica* L.) varieties. *Food Chemistry* 2008; 110(3): 620–626. doi: 10.1016/j.foodchem.2008.02.067
28. Ramirez JE, Zambrano R, Sepúlveda B, Simirgiotis MJ. Antioxidant properties and hyphenated HPLC-PDA-MS profiling of Chilean Pica mango fruits (*Mangifera indica* L. Cv. piqueño). *Molecules* 2013; 19(1): 438–458. doi: 10.3390/molecules19010438
29. Schieber A, Ullrich W, Carle R. Characterization of polyphenols in mango puree concentrate by HPLC with diode array and mass spectrometric detection. *Innovative Food Science & Emerging Technologies* 2000; 1(2): 161–166. doi: 10.1016/S1466-8564(00)00015-1

30. Ajila CM, Aalami M, Leelavathi K, Rao UP. Mango peel powder: A potential source of antioxidant and dietary fiber in macaroni preparations. *Innovative Food Science & Emerging Technologies* 2010; 11(1): 219–224. doi: 10.1016/j.ifset.2009.10.004
31. Ajila CM, Naidu KA, Bhat SG, Rao UP. Bioactive compounds and antioxidant potential of mango peel extract. *Food Chemistry* 2007; 105(3): 982–988. doi: 10.1016/j.foodchem.2007.04.052
32. Ajila CM, Rao LJ, Rao UP. Characterization of bioactive compounds from raw and ripe *Mangifera indica* L. peel extracts. *Food and Chemical Toxicology* 2010; 48(12): 3406–3411. doi: 10.1016/j.fct.2010.09.012
33. Ocampo ETM, Libron JAMA, Guevarra MLD, Mateo JMC. Phytochemical screening, phenolic acid profiling and antioxidant activity analysis of peels from selected mango (*Mangifera* spp.) genotypes in the Philippines. *Food Research* 2020; 4(4): 1116–1124. doi: 10.26656/fr.2017.4(4).025
34. Pacheco-Ordaz R, Antunes-Ricardo M, Gutiérrez-Uribe JA, et al. Intestinal permeability and cellular antioxidant activity of phenolic compounds from mango (*Mangifera indica* cv. Ataulfo) Peels. *International Journal of Molecular Sciences* 2018; 19(2): 514. doi: 10.3390/ijms19020514
35. Prasad KN, Hassan FA, Yang B, et al. Response surface optimisation for the extraction of phenolic compounds and antioxidant capacities of underutilised *Mangifera pajang* Kosterm. peels. *Food Chemistry* 2011; 128(4): 1121–1127. doi: 10.1016/j.foodchem.2011.03.105
36. Ranasinghe SDAE, Rajapakse CSK. A comparative study on phytochemical screening, antioxidant activity and photoprotective property of ethanolic extracts of peel and pulp of mango (*Mangifera indica* L. cv. TomEJC). Available online: http://ir.kdu.ac.lk/handle/345/6193 (accessed on 2 November 2023).
37. Ajila CM, Bhat SG, Prasada Rao UJS. Valuable components of raw and ripe peels from two Indian mango varieties. *Food Chemistry* 2007; 102(4): 1006–1011. doi: 10.1016/j.foodchem.2006.06.036
38. de Lourdes García-Magaña M, García HS, Bello-Pérez LA, et al. Functional properties and dietary fiber characterization of mango processing by-products (*Mangifera indica* L., *cvAtaulfo* and *Tommy Atkins*). *Plant Foods for Human Nutrition* 2013; 68: 254–258. doi: 10.1007/s11130-013-0364-y
39. Hassan FA, Ismail A, Hamid AA, et al. Characterisation of fibre-rich powder and antioxidant capacity of *Mangifera pajang* K. fruit peels. *Food Chemistry* 2011; 126(1): 283–288. doi: 10.1016/j.foodchem.2010.11.019
40. Sogi DS, Siddiq M, Dolan KD. Total phenolics, carotenoids and antioxidant properties of Tommy Atkin mango cubes as affected by drying techniques. *LWT—Food Science and Technology* 2015; 62(1): 564–568. doi: 10.1016/j.lwt.2014.04.015
41. Abdul Aziz NA, Wong LM, Bhat R, Cheng LH. Evaluation of processed green and ripe mango peel and pulp flours (*Mangifera indica* var. Chokanan) in terms of chemical composition, antioxidant compounds and functional properties. *Journal of the Science of Food and Agriculture* 2012; 92: 557–563. doi: 10.1002/jsfa.4606
42. Kim H, Moon JY, Kim H, et al. Antioxidant and antiproliferative activities of mango (*Mangifera indica* L.) flesh and peel. *Food Chemistry* 2010; 121(2): 429–436. doi: 10.1016/j.foodchem.2009.12.060
43. Banerjee N, Kim H, Krenek K, et al. Mango polyphenolics suppressed tumor growth in breast cancer xenografts in mice: Role of the PI3K/AKT pathway and associated microRNAs. *Nutrition Research* 2015; 35(8): 744–751. doi: 10.1016/j.nutres.2015.06.002
44. Patel GN, Kheni J. Mango seed kernel, a highly nutritious food, should we continue to trash or use? *Journal of Pharmacognosy and Phytochemistry* 2018; 7(4): 4–7.
45. Shobana V, Rajalakshmi K. Quantitative analysis of primary metabolites in *Mangifera indica* (unripe mango). *Rasayan Journal of Chemistry* 2010; 3(3): 597–599.
46. Tokas J, Punia H, Baloda S, Sheokand RN. Mango peel: A potential source of bioactive compounds and phytochemicals. *Austin Food Sciences* 2020; 5(1): 1035.
47. Yatnatti S, Vijayalakshmi D, Chandru R. Processing and nutritive value of mango seed kernel flour. *Current Research in Nutrition and Food Science Journal* 2014; 2(3): 170–175. doi: 10.12944/CRNFSJ.2.3.10
48. Ayala-Zavala JF, Vega-Vega V, Rosas-Domínguez C, et al. Agro-industrial potential of exotic fruit byproducts as a source of food additives. *Food Research International* 2011; 44(7): 1866–1874. doi: 10.1016/j.foodres.2011.02.021
49. Goñi I, Díaz-Rubio ME, Pérez-Jiménez J, Saura-Calixto F. Towards an updated methodology for measurement of dietary fiber, including associated polyphenols, in food and beverages. *Food Research International* 2009; 42(7): 840–846. doi: 10.1016/j.foodres.2009.03.010
50. Barbosa Gámez I, Caballero Montoya KP, Ledesma N, et al. Changes in the nutritional quality of five *Mangifera* species harvested at two maturity stages. *Journal of the Science of Food and Agriculture* 2017; 97(14): 4987–4994. doi: 10.1002/jsfa.8377
51. Chambial S, Dwivedi S, Shukla KK, et al. Vitamin C in disease prevention and cure: An overview. *Indian Journal of Clinical Biochemistry* 2013; 28(4): 314–328. doi: 10.1007/s12291-013-0375-3
52. Shaikh RN, Agarkar BS, Kshirsagar RB, Bachate AH. Studies on physical, chemical and mineral evaluation of mango (*Mangifera indica* L.). *The Pharma Innovation Journal* 2021; 10(6): 446–449.
53. Fowomola MA. Some nutrients and antinutrients contents of mango (*Magnifera indica*) seed. *African Journal of Food Science* 2010; 4(8): 472–476.

54. Elegbede JA, Achoba II, Richard H. Nutrient composition of mango (*Mangniferaindica*) seed kernel from Nigeria. *Journal of Food Biochemistry* 1995; 19(5): 391–398. doi: 10.1111/j.1745-4514.1995.tb00543.x
55. Gopalan C, Rama Sastri BV, Balasubramanian SC. *Nutritive Value of Indian Foods*. National Institute of Nutrition, Indian Council of Medical Research; 1993.
56. Tharanathan RN, Yashoda HM, Prabha TN. Mango (*Mangifera indica* L.), "The king of fruits"—An overview. *Food Reviews International* 2006; 22(2): 95–123. doi: 10.1080/87559120600574493
57. Bello-Pérez LA, García-Suárez FJL, Agama-Acevedo E. Mango carbohydrates. *Food* 2007; 1(1): 36–40.
58. Derese S. Guantai EM, Souaibou Y, Kuete V. *Mangifera indica* L. (Anacardiacea). In: *Medicinal Spices and Vegetables from Africa: Therapeutic Potential Against Metabolic, Inflammatory, Infectious and Systemic Diseases*. Elsevier; 2017. pp. 451–483.
59. Othman OC, Mbogo GP. Physico-chemical characteristics of storage-ripened mango (*Mangifera indica* L.) fruits varieties of Eastern Tanzania. *Tanzania Journal of Science* 2009; 35: 57–65.
60. Lalel HJD, Singh Z, Tan SC. The role of ethylene in mango fruit aroma volatiles biosynthesis. *The Journal of Horticultural Science and Biotechnology* 2003; 78(4): 485–496. doi: 10.1080/14620316.2003.11511653
61. Jahurul MHA, Zaidul ISM, Ghafoor K, et al. Mango (*Mangifera indica* L.) by-products and their valuable components: A review. *Food Chemistry* 2015; 183: 173–180. doi: 10.1016/j.foodchem.2015.03.046
62. Deshpande AB, Hemangi GC, Pranjali SO, et al. Data on changes in the fatty acid composition during fruit development and ripening of three mango cultivars (Alphonso, Pairi and Kent) varying in lactone content. *Data in Brief* 2016; 9: 480–491. doi: 10.1016/j.dib.2016.09.018
63. Vallarino JG, Pott DM, Cruz-Rus E, et al. Identification of quantitative trait loci and candidate genes for primary metabolite content in strawberry fruit. *Horticulture Research* 2019; 6: 4. doi: 10.1038/s41438-018-0077-3
64. Shahidi F, Janitha PK, Wanasundara PD. Phenolic antioxidants. *Critical Reviews in Food Science & Nutrition* 1992; 32(1): 67–103. doi: 10.1080/10408399209527581
65. Kalpna R, Mital K, Sumitra C. Vegetable and fruit peels as a novel source of antioxidants. *Journal of Medicinal Plants Research* 2011; 5(1): 63–71.
66. Zhu XM, Song JX, Huang ZZ, et al. Antiviral activity of mangiferin against herpes simplex virus type 2 in vitro. *Acta Pharmacologica Sinica* 1993; 14(5): 452–454.
67. Zheng MS, Lu ZY. Antiviral effect of mangiferin and isomangiferin on herpes simplex virus. *Acta Pharmacologica Sinica* 1989; 103: 160–165.
68. Stoilova I, Gargova S, Stoyanova A, Ho L. Antimicrobial and antioxidant activity of the polyphenol mangiferin. *Herb Polonica* 2005; 51: 37–44.
69. Engels C, Schieber A, Gänzle MG. Inhibitory spectra and modes of antimicrobial action of gallotannins from mango kernels (*MangiferaIndica* L.). *Applied and Environmental Microbiology* 2011; 77(7): 2215–2223. doi: 10.1128/AEM.02521-10
70. Vega-Vega V, Silva-Espinoza BA, Cruz-Valenzuela MR, et al. Antimicrobial and antioxidant properties of byproduct extracts of mango fruit. *Journal of Applied Botany and Food Quality* 2013; 86(1): 205–211. doi: 10.5073/JABFQ.2013.086.028
71. El-Desoukey RMA, Alijor NM, Alaotibi AD. The phytochemical and antimicrobial effect of mango (*Mangifera Indica* L.) peel extracts on some animal pathogens as eco-friendly. *Acta Scientific Microbiology*2020; 3(4): 34–39.
72. Sairam K, Hemalatha S, Kumar A, et al. Evaluation of anti-diarrhoeal activity in seed extracts of *Mangifera indica*. *Journal of Ethnopharmacology* 2003; 84(1): 11–15.
73. Alkizim FO, Matheka D, Abdulrahman FK, Muriithi A. Inhibitory effect of *Mangifera indica* on gastrointestinal motility. *Medicinal Chemistry and Drug Discovery* 2012; 2(1): 9–16.
74. Dhananjaya BL, Shivalingaiah S. The anti-inflammatory activity of standard aqueous stem bark extract of *Mangifera indica* L. as evident in inhibition of Group IA sPLA2. *Anais da Academia Brasileira de Cienccias* 2016; 88(1): 197–209. doi: 10.1590/0001-3765201620140574
75. Impellizzeri D, Talero E, Siracusa R, et al. Protective effect of polyphenols in an inflammatory process associated with experimental pulmonary fibrosis in mice. *British Journal of Nutrition* 2015; 114(6): 853–865. doi: 10.1017/S0007114515002597
76. Duricova D. What can we learn from epidemiological studies in inflammatory bowel disease? *Digestive Diseases* 2017; 35(1–2): 69–73. doi: 10.1159/000449086
77. Márquez L, Pérez-Nievas BG, Gárate I, et al. Anti-inflammatory effects of *Mangifera indica* L. extract in a model of colitis. *World Journal of Gastroenterology* 2010; 16(39): 4922–4931. doi: 10.3748/wjg.v16.i39.4922
78. Kim H, Banerjee N, Ivanov I, et al. Comparison of anti-inflammatory mechanisms of mango (*Mangifera Indica* L.) and pomegranate (*Punica Granatum* L.) in a preclinical model of colitis. *Molecular Nutrition & Food Research* 2016; 60(9): 1912–1923. doi: 10.1002/mnfr.201501008
79. Sharma SR, Dwivedi SK, Swarup D. Hypoglycaemic potential of *Mangifera indica* leaves in rats. *International Journal of Pharmacognosy* 1997; 35(2): 130–133. doi: 10.1076/phbi.35.2.130.13276
80. Aderibigbe AO, Emudianughe TS, Lawal BAS. Antihyperglycaemic effect of *Mangifera indica* in rat. *Phytotherapy Research* 1999; 13(6): 504–507. doi: 10.1002/(SICI)1099-1573(199909)13:6<504::AID-PTR533>3.0.CO;2-9

81. Perpétuo GF, Salgado JM. Effect of mango (*Mangifera indica*, L.) ingestion on blood glucose levels of normal and diabetic rats. *Plant Foods for Human Nutrition* 2003; 58: 1–12. doi: 10.1023/B:QUAL.0000040336.38013.83
82. Gondi M, Prasada Rao UJS. Ethanol extract of mango (*Mangifera indica* L.) peel inhibits α-amylase and α-glucosidase activities, and ameliorates diabetes related biochemical parameters in streptozotocin (STZ)-induced diabetic rats. *Journal of Food Science and Technology* 2015; 52(12): 7883–7893. doi: 10.1007/s13197-015-1963-4
83. Kim H, Kim H, Mosaddik A, et al. Induction of apoptosis by ethanolic extract of mango peel and comparative analysis of the chemical constitutes of mango peel and flesh. *Food Chemistry* 2012; 133(2): 416–422. doi: 10.1016/j.foodchem.2012.01.053
84. Corrales-Bernal A, Amparo Urango L, Rojano B, Maldonado ME. In vitro and in vivo effects of mango pulp (*Mangifera indica* cv. Azucar) in colon carcinogenesis (Spanish). *Archivos Latinoamericanos de Nutrición* 2014; 64(1): 16–23.
85. Abdullah AS, Mohammed AS, Rasedee A, et al. Induction of apoptosis and oxidative stress in estrogen receptor-negative breast cancer, MDA-MB231 cells, by ethanolic mango seed extract. *BMC Complementary Medicine and Therapies* 2015; 9(15): 45. doi: 10.1186/s12906-015-0575-x
86. Oka K, Saito F, Yasuhara T, Sugimoto A. A study of cross-reactions between mango contact allergens and urushiol. *Contact Dermatitis* 2004; 51(5–6): 292–296. doi: 10.1111/j.0105-1873.2004.00451.x
87. Percival SS, Talcott ST, Chin ST, et al. Neoplastic transformation of BALB/3T3 cells and cell cycle of HL-60 cells are inhibited by mango (*Mangifera indica* L.) juice and mango juice extracts. *The Journal of Nutrition* 2006; 136(5): 1300–1304. doi: 10.1093/jn/136.5.1300
88. van de Venter M, du Plessis-Stoman D, du Preez JGH. Combination treatment with oxaliplatin and mangiferin causes increased apoptosis and downregulation of nfišb in cancer cell lines. *African Journal of Traditional, Complementary and Alternative Medicines* 2011; 8(2): 177–184.
89. Shoji K, Tsubaki M, Yamazoe Y, et al. Mangiferin induces apoptosis by suppressing Bcl-xL and XIAP expressions and nuclear entry of NF-κB in HL-60 cells. *Archives of Pharmacal Research* 2011; 34: 469–475. doi: 10.1007/s12272-011-0316-8
90. Pithayanukul P, Leanpolchareanchai J, Saparpakorn P. Molecular docking studies and anti-snake venom metalloproteinase activity of Thai mango seed kernel extract. *Molecules* 2009; 14(9): 3198–3213. doi: 10.3390/molecules14093198
91. Nithitanakool S, Pithayanukul P, Bavovada R. Antioxidant and hepatoprotective activities of Thai mango seed kernel extract. *Planta Medica* 2009; 75(10): 1118–1123. doi: 10.1055/s-0029-1185507