Review Article

A Review on Ethnopharmacological Applications, Pharmacological Activities, and Bioactive Compounds of *Mangifera indica* (Mango)

**Meran Keshawa Ediriweera, Kamani Hemamala Tennekoon, and Sameera Ranganath Samarakoon**

*Institute of Biochemistry, Molecular Biology and Biotechnology, University of Colombo, 90 Cumaratunga Munidasa Mawatha, Colombo 03, Sri Lanka*

Correspondence should be addressed to Meran Keshawa Ediriweera; mk.ediriweera@gmail.com

Received 4 September 2017; Revised 29 October 2017; Accepted 19 November 2017; Published 31 December 2017

**Abstract**

*M. indica* L. is considered as one of the main tropical fruits in the world believed to be originated from Asia [1]. It has been reported that China, India, Brazil, Nigeria, Pakistan, Mexico, Thailand, and Philippine are well-known for mango cultivation with India being the highest mango cultivating country [2]. World production of mango is approximately 42 million tons per year which is second only to banana production. There are about 1000 mango varieties grown all over the world [2–4]. Mango is known by various names around the world, for example, Manja in Arabic, Mannko in Greek, Am or Ambi in Hindi, Amba in Sinhala, Mangu in French, Mango in Finnish, Mango in Dutch, Mangue in German, Mânguōin in Chinese, and Mampalam in Tamil [5]. Both ripe or unripe mango fruits are in human use as pickles, juice, oils, nectar, powder, sauce, cereal flakes, and jam [6]. Mango fruit peel and flesh are reported to be a rich source of fiber, vitamin C and A, essential amino acids, and polyphenols [7]. Mango seed has also been reported as a rich source of polyphenols [8]. Despite the common use of mango fruit as a food item, various parts of mango trees have also been used for medical purposes since ancient times, mostly in Southeast Asian and African countries [9]. Much evidence is found in literature on pharmacological and ethnomedical uses of *M. indica*; however, there is no complete review on phytochemicals, biological effects of phytochemicals, and pharmacological and ethnomedical properties of *M. indica*. Therefore, we present this review as an up-to-date and comprehensive evaluation which mainly includes phytochemicals, some reported bioactivities of phytochemicals, and pharmacological and ethnomedical properties of *M. indica*.

**1. Introduction**

*M. indica* L. is considered as one of the main tropical fruits in the world believed to be originated from Asia [1]. It has been reported that China, India, Brazil, Nigeria, Pakistan, Mexico, Thailand, and Philippine are well-known for mango cultivation with India being the highest mango cultivating country [2]. World production of mango is approximately 42 million tons per year which is second only to banana production. There are about 1000 mango varieties grown all over the world [2–4]. Mango is known by various names around the world, for example, Manja in Arabic, Mannko in Greek, Am or Ambi in Hindi, Amba in Sinhala, Mangu in French, Mango in Finnish, Mango in Dutch, Mangue in German, Mânguōin in Chinese, and Mampalam in Tamil [5]. Both ripe or unripe mango fruits are in human use as pickles, juice, oils, nectar, powder, sauce, cereal flakes, and jam [6]. Mango fruit peel and flesh are reported to be a rich source of fiber, vitamin C and A, essential amino acids, and polyphenols [7]. Mango seed has also been reported as a rich source of polyphenols [8]. Despite the common use of mango fruit as a food item, various parts of mango trees have also been used for medical purposes since ancient times, mostly in Southeast Asian and African countries [9]. Much evidence is found in literature on pharmacological and ethnomedical uses of *M. indica*; however, there is no complete review on phytochemicals, biological effects of phytochemicals, and pharmacological and ethnomedical properties of *M. indica*. Therefore, we present this review as an up-to-date and comprehensive evaluation which mainly includes phytochemicals, some reported bioactivities of phytochemicals, and pharmacological and ethnomedical properties of *M. indica*.

**2. Taxonomy and Botanical Description of *M. indica***

The genus *Mangifera* belongs to the family Anacardiaceae. Genus *Mangifera* approximately contains 69 different species...
with *M. indica* being the most common species in the same genus [10, 11]. *M. indica* plant is an evergreen broad canopy tree which grows to a height of 8–40 m [12]. *M. indica* bark is a thick brown-gray colour and is superficially cracked [13]. Leaves are 15–45 cm in length with variable sizes [13]. Leaf petiole has a variable length from 1–10 cm [13]. *M. indica* leaves (Figure 1) possess different shapes (lanceolate, ovate-lanceolate, linear-oblong, roundish-oblong, oval, and oblong) [13]. Green, red, and yellow leaves are seen in some mango varieties and upper leaf surfaces are normally shiny [13, 14]. In case of *M. indica* flowers, male and hermaphrodite flowers are produced in the same panicle; its size can vary from 6–8 mm in diameter. There are about 4000–5000 small flowers in panicles with red/purple spots on petals [13, 14]. Even though a large number of flowers present in panicles, very few will be developed as fruits. Flowering season is mainly from January to April and most of the flowers are subsesil and have a sweet smell. *M. indica* fruit (Figure 1) is drupe with different sizes, shapes, and colours. Fruit peel is green, yellow, red, or orange. Seeds are ovoid- or oblong-shaped covered with a hard endocarp having a woody fiber covering [15].

### 3. Ethnomedicinal Use

Various parts of *M. indica* (bark, leaves, roots, fruits, and flowers) have been used in traditional medicine for the treatment of various diseases and conditions. Ethnomedicinal uses of various parts of *M. indica* in different countries in the world have been summarized in Table 1.

### 4. Chemistry

#### 4.1. Phytochemicals in *M. indica*. A large variety of chemical compounds have been reported in *M. indica* [30]. Among these, polyphenols (flavonoids, xanthones, and phenolic acids) are the most abundant compound types in *M. indica* [31]. Mangiferin, gallic acid, catechins, quercetin, kaempferol, protocatechuic acid, ellagic acids, propyl and methyl gallate, rhamnetin, and anthocyanins are the major polyphenolic compounds found in *M. indica* [32]. Mangiferin is a well-known polyphenolic compound which has been extensively studied for its numerous biological properties [33]. The quantities of different polyphenols in mango depend on the part and variety of mango [34]. Antioxidant properties have been shown to be the main biological property of almost all the *M. indica* polyphenols [35]. Ascorbic acid and dehydroascorbic acid (oxidized form of ascorbic acid) are two other common polyphenols found in *M. indica* [36]. The amount of polyphenols is high in many parts of *M. indica*. Thus, a pure compound alone has been proven to be less effective than crude drugs, implying that the synergism of many *M. indica* polyphenols is essential for optimum biological activities [37, 38]. Carotenoids are another class of natural compounds found in plants. They are considered as natural organic pigments [39]. The bright yellow colour of *M. indica* fruit peel and flesh is due to the presence of carotenoids [39]. Biologically they are very good free radical scavengers [40]. It has been reported that carotenoids in *M. indica* are biosynthesized in the fruit and carotenoid concentration rises upon ripening [41]. β-carotene, luteoxanthin, violaxanthin, neoxanthin, zeaxanthin, and cryptoxanthin are the main carotenoids found in *M. indica* fruit flesh and peel [42]. Among these, β-carotene is the most abundant [42]. Terpenoids are a class of lipids, similar to terpenes, commonly found in the plant kingdom [43]. *M. indica* is reported to contain several terpenoids, including careen, oicimene, terpinolene, myrcene, or limonene [44]. These terpenoids are volatile and responsible for aroma in *M. indica* [45]. Lupeol and lupeollinolate are two other common triterpenoids found in mango [46]. Gallotannins (hydrolyzable tannins) are another class of chemical compounds found in *M. indica* bark, leaves, kernel, and fruit pulp [47]. The presence of tocopherols in *M. indica* has also been reported. Alpha-tocopherol, betatocopherol, and gamma-tocopherol are commonly found tocopherols in *M. indica* fruit peel and flesh [48]. Resorcinolic
### Table 1: Ethnomedicinal use of different parts of *M. indica* in the world.

| Country      | Part(s) used   | Ethnomedicinal use                                                                 | Reference(s) |
|--------------|----------------|----------------------------------------------------------------------------------|--------------|
| Bangladesh   | Bark           | Diarrhoea, gastric disorders, asthma, mouth sores, liver diseases, urinary tract infections, diabetes, rheumatism, leucorrhrea, bleeding hemorrhoids, lung hemorrhage, nerve disorders, syphilis, cough, and jaundice. Resins of the mango bark have been used for the treatment of cracked skin and feet. | [16]         |
|              | Seeds, fruit, and kernel | Urethrorrhea, vaginopathy, dysentery, diarrhoea, ophthalmia, and hemorrhage in lungs, uterus, and intestine |             |
|              | Roots          | Ulcers, syphilis, and leucorrhrea.                                               |              |
|              | Flowers        | Ulcers, diarrhoea, hemorrhage, anemia, dyspepsia, and dysentery. Hemorrhages, diarrhoea, ulcers, dysentery, cough, gall bladder and kidney diseases, wounds, throat diseases, and hiccups. The ash of burnt mango leaves has been used as a local application on burns and scalds. According to available reports, leaves have commonly been used for diabetes in the form of a decoction or powder. | [9, 19–23]   |
|              | Leaves         |                                                                                   |              |
| Benin        | Bark           | Hypotension and anemia                                                            | [17]         |
| Brazil       | Bark           | Scabies/itch                                                                     | [17]         |
| Canary Islands | Bark       | Diarrhea                                                                         | [17]         |
| Cuba         | Bark           | Mouth sores, tooth pain, cancer, diabetes, asthma, gastric disorders, and lupus   | [17]         |
| Fiji         | Bark           |                                                                                   | [17]         |
| Ghana        | Bark           | Hypertension and diabetes                                                         | [18]         |
| Guyana       | Bark           |                                                                                   | [17]         |
| Haiti        | Bark           |                                                                                   | [17]         |
|              | Bark           | Diarrhoea                                                                         | [17]         |
|              | Seeds, fruit, and kernel |                                                                                   |              |
|              | Roots          |                                                                                   |              |
|              | Flowers        |                                                                                   |              |
|              | Leaves         |                                                                                   |              |
| India        | Bark           | Diabetes, gastric disorders, asthma, mouth sores, leucorrhrea, bleeding hemorrhoids, lung hemorrhage, nerve disorders, syphilis, cough, and jaundice.                                                                 | [9, 19–23]   |
|              | Seeds, fruit, and kernel | Ophthalmia, hemorrhage in lungs, uterus and intestine, urethrorrhea, vaginopathy, dysentery, and diarrhoea |              |
|              | Roots          | Ulcers, syphilis, and leucorrhrea.                                               |              |
|              | Flowers        | Ulcers, diarrhoea, hemorrhage, anemia, dyspepsia, and dysentery. Diarrhoea, ulcers, diabetes, dysentery, cough, gall bladder and kidney diseases, hemorrhages, wounds, diseases in throat and hiccups, burns, and scalds.                                                                 |              |
|              | Leaves         |                                                                                   |              |
| Madagascar   | Bark           |                                                                                   | [17]         |
| Mali         | Bark           |                                                                                   | [17]         |
| Nicaragua    | Bark           | Wounds                                                                            | [17]         |
| Nigeria      | Leaves         | Leaf decoctions have been commonly used to treat diabetes and malaria             | [24, 25]     |
| Pakistan     | Bark           |                                                                                   | [17]         |
|              | Leaves and seeds | Asthma, bronchitis, cough, and throat problems                                     | [26, 27]     |
| Peru         | Leaves         | Bronchitis, colds, and inflammation                                              | [28]         |
| Senegal      | Bark           |                                                                                   | [17]         |
| Sri Lanka    | Bark           | Menorrhagia, leucorrhrea, piles, and hemorrhages of the lungs and intestine        | [29]         |
|              | Leaves         |                                                                                   |              |
|              | Flowers        | Diseases of the lungs, coughs, and asthma                                          |              |
| Tanzania     | Bark           |                                                                                   | [17]         |
| Tonga        | Bark           |                                                                                   | [17]         |
lipids (phenolic lipids) are another class of natural compounds found in *M. indica* [49]. The isolation of a wide range of resorcinolic lipids with different biological properties has been reported from *M. indica* fruit peels, flesh, and bark [49]. The isolation of a novel resorcinolic lipid from the bark of *Mangifera zeylanica* (endemic Sri Lankan mango) with anticaner effects has been presented in a study carried out by us [50]. It was thought that halogenated compounds are limited only to marine plants and microorganisms. However, occurrence of halogenated compounds in the bark of *M. indica* has been reported in a study conducted in India [51].

A recent study carried out by us also reported the isolation of two novel halogenated compounds (chloromangiferamide and bromomangiferic acid) from the bark of *M. zeylanica* [52]. Structures of some common compounds present in *M. indica* are shown in Figures 2(a) and 2(b). Quercetin and mangiferin are commonly found in *M. indica* are shown in Figures 2(a) and 2(b). Quercetin and mangiferin are most commonly found in *M. indica*. As these two compounds containing food items (including mango fruits) are very common in human diet, studies on their safety and toxicity have been well-documented [17, 53–55]. Moreover, kaempferol, another well-known mango compound, has also been subjected to various safety and toxicity studies in order to validate its uses in human diet [56–58]. In most of the studies it has been mentioned that quercetin mangiferin and kaempferol are less toxic in studied animal models.

### 4.2. Reported Phytochemicals in Different Parts of *M. indica*

#### 4.2.1. Leaves

Amino acids include alanine, glycine, valine, tyrosine, leucine, and γ-aminobutyric acid. Polyphenols and phenolic acids include protocatechuic acid, gallic acid, hyperin, catechin, quercetin, mangiferin, kainic acid, ethyl digallate, ellagic acid, and shikimic acid. Alcohols include methylic, ethyl, and isobutyl alcohols. Terpenes include α-pinene, β-pinene, δ-elemene, taraxerol, β-elemene, α-cubebene, camphene, γ-cadinene, lupeol, friedelin, linalool, β-bulnesene, α-guaiene, humulene, α-farnesene, myrcene, car-3-ene, limonene, β-ocimene, γ-terpinene, and α-terpinolene. Phenylpropanes include estragole, methylulegol and elemicin. Sterols include α, β, and γ-sitosterol [59–64].

#### 4.2.2. Fruit Peel and Flesh

Triterpenes and triterpenoids include cycloartenol, α-amyrin, β-amyrin, ocoitol, 3b-hydroxy cycloartan-24-en-26-al, 24-methylene-cycloartan-3b, 26-diol, dammarenediol II, and psi-taraxastane-3b. Polyphenols and phenolic acids include ascorbic acid, quercetin, mangiferin, quercetin 3-ara, quercetin 3-rha, isomangiferin gallate, mangiferin gallate, methy methylferonate, methyl mangiferolate, tetra-O-galloylgucose, hexa-O-galloylgucose, methyl isomangiferolate, caffeic acid, ferulic acid, gallic acid, cinnamic acid, vanillin, rhamnetin-3-O-galactoside, kaempferol, and kaempferol-hexose. Resorcinolic lipids include 5-(11Z-7-heptadecenyl)-resorcinol and 5-(8Z,11Z-7-heptadecadienyl)-resorcinol. Carotenoids include β-carotene, cis-violaxanthin, neochrome, cis-neoxanthin, luteoxanthin, zeaxanthin, and 9- or 9′-cis-lutein. Long-chain fatty acids include oleic acid, linoleic acid, linolenic acid, and n-pentacosanol [49, 59–64].

#### 4.2.3. Root

Triterpenes and triterpenoids include friedelin, friedelan-3b-ol, α-amyrin, β-amyrin, and cycloartenol. Sterols include β-sitosterol and 3-methoxy-2-(4′-methyl benzoyl)-chromone [59–64].

#### 4.2.4. Bark

Polyphenols and phenolic acids include protocatechuic acid, catechin, mangiferin, benzoic acid, kainic acid, gallic acid, shikimic acid, and kaempferol. Triterpenes and triterpenoids include cycloart-24-en-3b, 26-diol, 3-keto-dammar-24(E)-en-20S, 26-diol, friedelin, mangoucomarin, manglepulone, manghopanal, cycloartan-3β-30-diol cycloartan-3b, 24, 27-triol, mangoleanone, mangiferolic acid ethyl ester, mangiferolate A and mangiferolate B, and 29-hydroxy-mangiferonic acid. Halogenated amide includes 3-chloro-N-(2-phenylethyl) propenamide. Long-chain hydrocarbons include N-triacontane, N-tetracosane, and 9,12-tetradecadiene-1-ol-acetate. Terpenoid saponins include indicoside A and B. Amino acids include alanine, glycine, and γ-aminobutyric acid [51, 59–65].

#### 4.2.5. Seed and Kernel

Long-chain hydrocarbons and fatty acids include stearic acid, eicosanoic acid, linoleic, linolenic, oleic acid, arachidonic acid, and palmitic acid. Sterols include stigmasterol, sitosterol, and campesterol. Triterpenes and triterpenoids include α-pinene, β-pinene, myrcene, and limonene. Polyphenols and phenolic acids include ascorbic acid, mangiferin, quercetin, and gallic acid [59–67].

#### 4.2.6. Flowers

Amino acids include threonine, valine, alanine, and tryptophan. Polyphenols and phenolic acids include gallic acid, mangiferin, quercetin, and ellagic acid. Triterpenes and triterpenoids include β-pinene, nerol, limonene, α-phellandrene, and α-pinene [59–68].

### 5. Pharmacological Properties of *M. indica*

A number of *in vitro* and *in vivo* studies have been carried out to reveal various pharmacological potentials of *M. indica*. Different parts of *M. indica* trees have been demonstrated to exert anticancer, anti-inflammatory, anti-diabetic, antioxidant, antibacterial, antifungal, antihelmintic, gastroprotective, hepatoprotective, immunomodulatory, antiplasmodial and antihyperlipemic effects [69]. Many of these pharmacological studies on different parts (as organic extracts or decoctions) of *M. indica* trees have been carried out to validate the ethnomedical uses of the plant in traditional medicine in the treatment of several diseases and conditions. A large number of pharmacological studies on *M. indica* have been conducted mainly in India and Bangladesh. A considerable number of pharmacological studies have also been reported from countries like Brazil, Nigeria, and Iran. Some experimentally proven pharmacological properties of different parts of *M. indica* trees have been described in detail in the following section.

#### 5.1. Antioxidant Properties of *M. indica*

Antioxidants are substances which inhibit/neutralise oxidative damage by trapping free radicals to a target molecule [70]. Several classes of natural compounds including polyphenols, phenolic acids, and flavonoids are reported as good free radical scavengers [71].
It has been reported that reactive oxygen species (ROS) and some other oxidants cause various disorders and diseases to human [71]. Humans possess antioxidative mechanisms which fight against reactive oxygen species (ROS) and some other oxidants by deactivating free radicals before they attack targets in human body [72]. Naturally occurring antioxidants have gained much attention recently as they possess a remarkable ability to fight against free radicals and reactive
oxygen species [72]. As almost all the parts of the mango tree are reported to possess polyphenols, which are well-known antioxidants, most of the pharmacological studies have proven that antioxidant properties with extract(s) of various parts of the M. indica tree are related to polyphenolic content. The following section will summarize some selected studies which illustrate antioxidant effects of different parts of M. indica. A recent study carried out by Thambi et al. 2016 [73] evaluated antioxidant effects of mango peel powder and proved that the acetone extract of the M. indica peel exerts strong radical scavenging effects. A research carried out by Abbasi et al. 2017 [74] with nine mango varieties (Royal mango, Thai mango, Egg mango, Luzon, Narcissus, Big Tainong, Keitt, Australian mango, and Small Tainong) found in China found that the peel of Small Tainong (Xiao Tainong) variety exerts the highest antioxidant potential among the tested varieties. Another study conducted by Sultana et al. 2012 [75] measured the antioxidant potential of water-methanol extracts of the peels of two mango varieties (Langra and Chaunsa) grown in Pakistan. Among these two peel extracts, water-methanol extract of Chaunsa exhibited strong antioxidant effects than Langra. Kim et al. 2010 [76] who studied antioxidant effects of ethanolic extracts of mango peel and flesh showed potent antioxidant effects of mango peel extracts compared to flesh extracts. Effect of temperature on the antioxidant activity of mango peel extracts (a variety found in Spain) was studied by Dorta et al. 2012 [77]. Methanol, ethanol, acetone, water, methanol-water, acetone-water, and ethanol-water extracts were subjected to radical scavenging activity and methanol-water, acetone-water and ethanolic-water extracts were found to possess high antioxidant capacity when the temperature is increased from 50–70°C. A number of studies around the world have evaluated the antioxidant effects of mango fruit flesh. A study conducted with methanol extracts of fruit flesh of two mango varieties (Americana and Jose) grown in France by September-Malaterre et al. 2016 [78] has shown that methanol extracts of both these varieties exert antioxidant effects. A comparative study has been carried out with fruit flesh of five mango varieties (Langara, Fazli, Amrupali, Himsagor, and Ashwina) grown in Bangladesh [79]. Methanolic extracts of all the tested mango varieties exerted considerable antioxidant effects and the fruit flesh extract of Langra exerted the highest effect. Another comparative study carried out with methanol/dichloromethane and aqueous extracts of fruit flesh of four Egyptian mango varieties (Zebdia, Sukkari, Taimor, and Hindi) showed that methanol/dichloromethane extracts of all the varieties have prominent antioxidant effects than the aqueous extracts [80]. Antioxidant potential of ethanolic extract of the seed of an M. indica variety grown in Malaysia has been reported by Norshazila et al. 2010 [81]. Pitchaon, 2011 [82], has demonstrated antioxidant capacity of seed kernel obtained from a mango variety (Chok-Anan) grown in Thailand. Two kernel extracts have been prepared by acid hydrolysis and shaking in ethanol. The results of this study showed that the extract prepared by acid hydrolysis has a high antioxidant potential than the extract prepared by shaking in ethanol. Sultana et al. 2012 [75] have presented antioxidant potential of water-methanol extracts of the bark of two M. indica varieties (Langra and Chaunsa) grown in Pakistan. The bark of the variety Chaunsa exerted a higher antioxidant potential than Langra. Antioxidant effects of methanolic extract of M. indica leaves have been reported by Mohan et al. 2013 [83]. They showed that ethyl acetate and butanol fractions obtained after solvent partition of the crude methanol extract have antioxidant effects.

5.2. Anti-Inflammatory Effects of M. indica. Several naturally found polyphenols are reported to possess anti-inflammatory effects via inhibition of nuclear factor kappa-B (NF-κB) [84]. However, anti-inflammatory activities of these compounds depend on their chemical structures and their cellular targets [84]. Production of a large amount of proinflammatory cytokines (IL-1, 2 and 6 and TNF) increase the expression of enzymes such as COX-2 and iNOS which are associated with anti-inflammations [85]. Nuclear factor kappa-B (NF-κB), a transcriptional factor, is reported to control expression of proinflammatory cytokines [86]. Ulcerative colitis and inflammatory bowel disease are considered as main diseases that occur due to chronic inflammation [87]. Several studies have shown that mango extracts can exert anti-inflammatory effects in experimental models of ulcerative colitis. In a recent study, treatment with a mango beverage prepared from fruit (Mexican variety) which consists of polyphenols and vitamins has caused attenuation of colitis symptoms by expressing the PI3K/AKT/mTOR pathway [88]. Another study conducted by the same authors showed that the same mango polyphenols-rich beverage can inhibit the IGF-IR/AKT/mTOR pathway in ulcerative colitis [89]. In another study, aqueous extract of stem-bark extract from M. indica rich in polyphenols and flavonoids was found to attenuate colitis symptoms in a model of colitis [90]. Attenuation of symptoms was accompanied by a reduction in COX-2, TNFR-2, TNF-α, and iNOS levels in colonic tissue. Gout is considered as one of the most common causes of inflammatory arthritis. Deposition of monosodium urate crystals on local tissue and joints is the major clinical manifestation of gout [91]. Antigouty arthritis effects of ethanol extract of M. indica leaves have been studied by Jiang et al. 2012 [91]. Oral administration of ethanol extract of M. indica leaves has caused reduction in IL-1β and TNF-α mRNA levels and ankle swelling in a rat with gouty arthritis induced by monosodium urate [91].

Vimang is an aqueous extract of M. indica (stem-bark) used in Cuba as a natural supplement [92]. A number of in vivo and in vitro studies have been conducted with Vimang to demonstrate its antioxidant effects. A study carried out by Garrido et al., 2004 [92], has shown that administration of Vimang can reduce arachidonic acid (AA) and phospholipidate acetate-induced ear edema in mice. Reduction in myeloperoxidase (MPO) activity was observed in phospholipidate acetate-induced mice. Inhibition of tumor necrosis factor alpha (TNF) serum levels was also observed in both models of inflammation after administration of Vimang. In vitro evaluations carried out with Vimang have shown that it can inhibit PGE2 (prostaglandin E2) or LTβ4 (Leukotriene B4) in macrophage cells (RAW264.7) induced with proinflammatory stimuli. Another study conducted...
by Garrido et al., 2001 [93], has also shown possible anti-inflammatory effects of Vimang. Carrageenan and formalin-induced oedema in mice were used to study anti-inflammatory effects in this study. Results of this study have shown that Vimang can significantly inhibit carrageenan- and formalin-induced oedema (in rat, guinea pigs, and mice). Moreover, Garrido et al., 2004 [94], have shown for the first time that Vimang can block TNFx (tumor necrosis factor alpha) and inhibit the production of NO (nitric oxide) in macrophages (RAW264.7 and N9) and in mice model of septic shock. Martinez et al., 2000 [95], have evaluated in vitro antioxidant effects of Vimang with the help of some commonly accepted assays. Strong radical scavenging activity and a significant inhibition of peroxidation of rat-brain phospholipids by Vimang were observed in this study.

Neuroprotective efficacy of mangiferin in doxorubicin (DOX)-induced rats has been studied by Siswanto et al., 2016 [96]. Brain damage in male Sprague-Dawley rats has been induced by doxorubicin, and mangiferin has been given to brain damage-induced rats for 7 weeks. Results of this study have shown that mangiferin can effectively reverse the brain damage induced by doxorubicin. Cognitive enhancing effects and improvement in memory impairment by \textit{M. indica} fruit pulp extract (ethanol) were studied by Wattanathorn et al., 2014 [97]. To determine cognitive enhancing effects and improvement in memory impairment, male Wistar rats have been administered with the neurotoxin AF64A and given the fruit peel extract. Results of the study have shown increased cholinergic neurons density and decreased oxidative stress in rates, which illustrates possible cognitive enhancing effects of \textit{M. indica} fruit pulp. Neuroprotective activities of methanol and aqueous extracts of \textit{M. indica} leaf have been studied by Kawpoomhae et al., 2010 [98]. Neuroprotective effects of methanol and aqueous extracts were evaluated by determining protection of neuroblastoma cells from H$_2$O$_2$-induced oxidative damage and results showed that methanol extract and aqueous extract can effectively protect H$_2$O$_2$-induced neuroblastoma cells from oxidative damage.

Liver, a vital organ in the human body, mainly regulates metabolism and detoxification of toxic substances [166]. It plays an important role by removing reactive oxygen species (ROS) and helps maintains oxidative balance [167]. A number of chemical substances that cause hepatotoxicity by inducing oxidative damage and lipid peroxidation have been identified [168]. Hepatotoxicity is currently treated with drugs that can activate p450 enzyme mechanism either by stopping or inducing the metabolic activity of enzymes [169]. Investigation of phytochemicals with hepatoprotective effects and their mechanism of action has gained much attention. Many authors have investigated hepatoprotective effects of certain plant extracts/pure compounds including \textit{M. indica}. Ebeid et al. 2015 [170] have demonstrated hepatoprotective effects of an aqueous extract of leaves of an \textit{M. indica} variety found in Egypt where they found that the aqueous extract successfully inhibited CCl$_4$-induced hepatocellular toxicity in albino rats. Results were further confirmed by analyzing lipid profiles, high-density lipoprotein (HDL), and malondialdehyde (MDA) levels. An in vitro study carried out by Hiranagahalli et al. 2012 [171] has shown that methanol/acetone extract of \textit{M. indica} bark can exert hepatoprotective effects in tert-butyl hydroperoxide-induced HepG2 cells in a dose-dependent manner. Hepatoprotective effects of lupeol and aequous \textit{M. indica} pulp extract (collected from Lucknow, India) have been studied in 7,12-Dimethylbenz[a]anthracene (DMBA)-induced Swiss albino mice. Lupeol and mango \textit{M. indica} extract were found to be effective in the treatment of liver injury caused by oxidative stress [172]. Pourrahmad et al. 2010 [173] investigated hepatoprotective effects of an aqueous extract of a mango fruit variety collected from Iran and demonstrated that the extract exerts hepatoprotective effects in cumene hydroperoxide-induced rat hepatocytes. Hepatoprotective effects of an ethanolic extract of kernel of a Thai \textit{M. indica} variety have been also reported by Nithtanakool et al. 2009 [174]. Significant hepatoprotective effects of the ethanolic extract of kernel have been reported in rats with liver injuries induced by carbon tetrachloride (CCl$_4$).

5.3. Analgesic Effects. Analgesic effects of stem-bark aqueous extract of \textit{M. indica} have been studied by Ojewole, 2005 [175]. Hot-plate and acetic acid test models of pain in mice have been used to study analgesic effects, and results of this study have demonstrated significant analgesic effects in mice with nociceptive pain. Islam et al. 2010 [176], have demonstrated analgesic effects of methanol extract of leaves of \textit{M. indica}. Results have demonstrated a significant reduction in writhing response in an acetic acid-induced writhing response rat model. Garrido et al., 2001 [93], have shown possible analgesic effects of Vimang. Acetic acid-induced abdominal restriction and formalin-induced licking were used to test analgesia. Results of this study have shown that Vimang can exhibit antinociceptive effects in mice. Moreover, a considerable dose-dependent inhibition in formalin-induced pain was also observed in rats after administration of Vimang.

5.4. Immunomodulatory Effects of \textit{M. indica}. Immunomodulation is a process that adjusts the immune system of an organism upon any change caused by a foreign agent [177]. Immunomodulation can be of two types, namely immunostimulation and immunosuppression [178]. Immunostimulation includes stimulation of the immune system with immunostimulating agents that activate components of the immune system (macrophages, certain T-lymphocytes and granulocytes) [178]. In immunosuppression, efficiency of the immune system decreases [178]. As clinically used immunomodulating drugs cause serious side effects, it is necessary to discover immunomodulating agents with fewer side effects [179]. Garrido et al. 2005 [180] have shown immunomodulatory activity of bark aqueous extract of a mango variety collected from Cuba. Inhibition of proliferation of T-cells and NF- $\kappa$B transcription factor were reported in this \textit{in vitro} study suggesting possible immunomodulation. Another study conducted in Cuba with an aqueous extract of mango bark has also shown \textit{in vivo} immunomodulatory effects, where NOS-2, COX-2, IL-1$\beta$, TNF- $\alpha$, and colony-stimulating factor (GM-CSF) mRNA levels were found to decrease in experimental mice model(s) [181]. Makare et al. 2001 [182] have assessed immunomodulatory effects of an ethanolic extract of mango bark rich in mangiferin in Swiss
albino mice. Administration of the ethanolic bark extract increased delayed type hypersensitivity (DTH) and humoral antibody (HA) titer suggesting possible immunostimulation by the extract. Immunostimulatory effects of a mango kernel powder in a species of fish (Labeo rohita) infected with Aeromonas hydrophila have been studied by Sahu et al. 2007 [183], where increased immunological parameters (lysozyme activity, superoxide anion production, and bactericidal activity) were detected in fish fed with mango kernel powder. Moreover, a recent study has shown that a hexane leaf extract from M. indica collected from Varanasi, India, possesses immunomodulatory effects in RAW 264.7 cells. Immunomodulatory effects were confirmed by analyzing intracellular NO levels, where a significant increase in response to the leaf hexane extract was observed. Furthermore, oral administration of the leaf hexane extract has also caused increased white blood cells, hemoglobin concentration, and temporary increase in the size of spleen and thymus in cyclophosphamide-induced myelosuppressed mice, which indicates immunostimulation in bone marrow hematopoietic cells and white blood cells [184].

5.5. Antitumoral Effects of M. indica. Cancer is considered as one of the major causes of death in the world and any practical solution in fighting this dreadful disease would be very important in public health [185]. It is the main cause of death in economically developed countries and the second leading cause of death in economically developing countries [186]. Cancer is caused by several factors such as chemicals, radiations, tobacco, infectious microorganisms, hormones, gene mutations, and immune conditions [187]. Though, modern surgeries have considerably reduced the cancer death rates, use of radiotherapy, chemotherapy, and hormone therapy treatments cannot completely reduce the number of deaths due to cancer [188]. Plant-based treatments have been used in traditional medicine to treat different diseases including cancer since ancient times and a number of in vitro and in vivo studies have already been reported in literature to validate these uses [189]. Different organic extracts and decoctions prepared from parts of mango trees and compounds isolated from mango trees have shown anticancer effects.

A recent study by Abbasi et al. 2017 [74] demonstrated antiproliferative effects of fruit peel and pulp of several mango varieties (Royal mango, Thai mango, Egg mango, Luzon Narcissus, Big Tainong, Keitt, Australian mango, and Small Tainong) grown in China. They showed that the acetone extracts of mango peel and pulp exerted antiproliferative effects in HepG2 cells. Another study carried out by Kim et al. 2012 [190] has shown that the ethanolic extract of M. indica peel can induce apoptosis in human cervical adenocarcinoma HeLa cells. Apoptotic effects of the peel ethanolic extract have been studied by analyzing expression of apoptosis-related proteins Bax, Bcl-2, Bid, and caspases (3, 8, and 9) in this study. Phytochemical investigation of peel ethanolic extract has revealed that it contains some reported anticancer compounds such as quercetin 3-O-galactoside, gallic acid, linoelic acid, alpha-tocopherol, mangiferin gallate, mangiferin, kaempferol 3-glucoside and quercetin-3-O-arabinopyranoside. Protective effects of ethanolic extracts of mango fruit peel and flesh (a Korean variety) samples in H2O2-induced cytotoxicity in HepG2 cells have also been studied by this research group [76]. A study carried out by Corrales-Bernal et al. 2014 [191] has shown that aqueous extract of mango fruit flesh possesses antiproliferative effects in human colon adenocarcinoma cell line (SW480) and in mouse model with colorectal cancer. Antiproliferative effects of methanol extracts of peel and flesh of three mango cultivars (Kensington Pride (KP), Nam Doc Mai (NDM), and Irwin (IW)) found in Australia were studied by Taing et al. 2015 [192]. They have demonstrated that peel methanol extract of NDM can only inhibit the proliferation of MCF-7 breast cancer cells. Antitumor effects of mango polyphenols-rich fruit flesh extracts in human breast cancer xenografts mice have been studied by Banerjee et al. 2015 [193]. This study has proven that mango polyphenols-rich fruit pulp extract has a potential to target PI3K/AKT pathway in breast cancer. Anti-carcinogenic effects of a crude (methanol: acetone: water: 1:1:1) fruit peel extract of some selected mango varieties (Kent, Francis, Atkins, Ataulfo, Tommy, and Haden, found in Brazil) have been evaluated in leukemia (Molt-4), lung (A-549), triple negative breast (MDA-MB-231), prostate (LNCap), and colon (SW-480) cancer cells by Noratto et al. 2010 [194]. Among the studied mango varieties, two (Ataulfo and Haden) were more sensitive to SW-480 and MOLT-4 cells. Moreover, apoptotic effects of Ataulfo and Haden varieties have also been studied in SW-480 cells in this study. Induction of apoptosis by aqueous extract of mango fruit peel rich in lupeol has been carried out in testosterone-induced mouse prostate and human prostate cancer cells (LNCaP) by Prasad et al. 2007 [195]. Antiproliferative effects of two extracts (pectinase and Soxhlet extracts) of mango flesh found in Australia have shown in oestrogen receptor positive (MCF-7) breast cancer cells by Wilkinson et al. 2011 [196].

Induction of oxidative stress mediated apoptosis by ethanolic extract of M. indica seed in triple negative breast cancer cells (MDA-MB-231) has been reported by Abdullah et al. 2015 [197]. In this study, apoptotic effects of ethanolic extract of M. indica seeds were evaluated by analyzing apoptosis-related marker proteins such as Bax, Bcl-2, cytochrome c, and caspases (3, 8, and 9). Involvement of oxidative stress markers such as reactive oxygen species (ROS), glutathione (GSH), and malondialdehyde (MDA) levels in apoptosis has also been studied. Another study [198] carried out by the same research group reported oxidative stress mediated apoptosis by ethanolic extract of mango seeds in oestrogen receptor positive breast (MCF-7) cancer cells. Nguyen et al. 2016 [199] have demonstrated cytotoxic effects of methanol bark extract of M. indica in pancreatic cancer cells (PANC-1). Isolation of two novel cycloartane-type triterpenes, namely, mangiferololate A and mangiferololate B, has also been reported in the same study. Studies on the anticancer effects of mango leaves are limited. Cytotoxic effects of ethanolic leaf extract of an M. indica variety grown in Thailand were investigated by Ganongpichayagri et al. 2017 [200], but a very low cytotoxic potential by ethanolic extract has been reported in all the cancer cell lines tested. Hepatoblastoma (HepG2), gastric carcinoma (Kato-III), bronchogenic carcinoma (Chago K1), ductal carcinoma
Evidence-Based Complementary and Alternative Medicine

(6.474), and colon adenocarcinoma (SW 620) cells were used in this study. Cytotoxic and apoptotic potential of the bark of two mango varieties (Rata Amba and Kartha Kolamban Amba) grown in Sri Lanka in breast (MCF-7 and MDA-MB-231) and ovarian cancer (SKOV-3) cells has been recently reported by us [201]. In this study we found that methanolic extracts of bark of two mango varieties exert cytotoxic and apoptotic potential in breast and ovarian cancer cells. In addition to these findings, our recent findings have demonstrated that the hexane extract of bark and the chloroform extract of the fruit peel of Mangifera zeylanica, a plant endemic to Sri Lanka (Sri Lankan mango), can induce apoptosis in breast and ovarian cancer cells [202, 203]. Results of our studies showed that the hexane extract of bark of M. zeylanica has promising cytotoxic effects in breast (MCF-7 and MDA-MB-231) and ovarian cancer (SKOV-3) cells with less cytotoxicity to normal mammary epithelial (MCF-10A) cells [202]. Hexane extract also showed apoptotic effects in these cancer cells. Phytochemical investigation by GC-MS analysis of the active fractions of the hexane extract revealed few unknown compounds and we isolated a new resorcinolic lipid which was cytotoxic to MCF-7 breast cancer cells [50]. Furthermore, we isolated two new halogenated compounds namely chloromangiferamide and bromomangiferic acid from the chloroform extract of M. zeylanica bark [52]. Of these chloromangiferamide was cytotoxic only to MDA-MB-231 cells whereas bromomangiferic acid had no cytotoxic activity. Studies with the M. zeylanica fruit peel and flesh demonstrated that chloroform extract of fruit peel can induce apoptosis in MCF-7 breast cancer cells through an oxidative stress mechanism. Phytochemical identification of the peel chloroform extract of M. zeylanica showed presence of some reported anticancer compounds such as linoleic acid and α-tocopherol [203]. Mangiferin is a well-known bioactive xanthone found in various parts of the mango tree. A number of studies have been carried out to illustrate antitumoral effects of mangiferin in various cancer cell lines such as breast, lung, ovary, brain, and cervix, and possible antitumoral mechanisms of mangiferin in several cancer cell lines have also been well-documented [204].

5.6. Antibacterial Effects of M. indica. Resistance to antibiotics has become one of the biggest problems worldwide [205]. Unnecessary use of antibiotics for viral infections, prolong use of antibiotics for diseases, wrong prescriptions given to patients without determining the exact cause of infection, and discontinuation of antibiotics without completing treatments by patients are some of the major causes for occurrence of antibiotic resistance [206]. Approximately half of all deaths in tropical countries are due to bacterial infections [207]. Therefore, discovery of novel antibacterial agents for drug resistant bacteria is essential. A number of studies have proven the antibacterial effects of certain plant crude drugs and natural compounds isolated against drug resistant bacteria [208]. Herbal remedies for bacterial infections have gained much attention recently as they are readily available, cause fewer side effects, and cheap.

Various studies have been conducted with the extracts of roots, leaves, bark, fruit peel and flesh, and kernel of M. indica to investigate antibacterial properties. Among these parts, mango kernel and leaves are the most studied parts for antibacterial effects. A study carried out by Mutua et al. 2017 [209] with four M. indica varieties grown in Kenya (Apple, Ngowe, Sabine, and Kent) found that the methanol extracts of kernels of Apple and Sabine varieties exert strong inhibitory effects against Escherichia coli. Antibacterial effects of hexane, chloroform, benzene, methanol, and water extracts of kernel of an M. indica variety found in Tamil Nadu, India, have been reported by Rajan et al. 2011 [210]. The methanolic extract of the kernel was more potent in inhibiting the growth of Shigella dysenteriae, a causative agent for diarrhoea. Aqueous kernel extracts of two other M. indica varieties (Bagnapalli and Senthura) found in Tamil Nadu (Vellore) were subjected to study antibacterial effects against Staphylococcus aureus and Pseudomonas aeruginosa by Alok et al. 2013 [211]. Aqueous extracts of Bagnapalli variety exerted a higher effect than the Senthura variety. Antibacterial effects of kernels obtained from three mango varieties (Black Gold, Lemak, and Waterlily) grown in Malaysia were studied by Mirghani et al. 2009 [212]. Kernel samples were extracted to ethanol, methanol, acetone, and phosphate buffer saline and were subjected to antibacterial studies against S. aureus, E. coli, P. aeruginosa and Bacillus subtilis. The results of this study showed that the ethanol and methanol extracts of Lemak have the highest antibacterial potential. Inhibitory effects of methanolic kernel extract (rich in polyphenols) of a Japan M. indica variety against 43 bacterial species have been evaluated by Kabuki et al. 2000 [213]. Methanolic kernel extract of this variety was found to be more active against Gram-positive bacteria in tested organisms.

A number of studies have also been carried out to evaluate antibacterial effects of different extracts of M. indica leaves worldwide. A recent study carried out by Diso et al. 2017 [214] showed that chloroform and aqueous extracts of leaves of an M. indica variety collected in Nigeria possess antibacterial effects against isolates of S. aureus. Chloroform extract of leaves was found to be more inhibitive than the aqueous extracts tested. In vitro antibacterial effects of water, methanol, and acetone extracts of leaves of another M. indica variety grown in Nigeria have been tested on Shigella flexneri, E. coli, S. aureus, Streptococcus pyogenes, Bacillus cereus, P. aeruginosa, Streptococcus pneumoniae, Proteus mirabilis, and Salmonella typhi by Doughari and Manzara, 2008 [215]. Islam et al. 2010 [176] showed the antibacterial effects of leaf ethanol extract of a mango variety found in Bangladesh. Growth inhibition of Staphylococcus aureus, Streptococcus agalactiae, B. cereus, Bacillus megaterium, B. subtilis, and Lactobacillus bulgaricus bacterial species by methanolic leaf extract was observed in the study. An acetone extract of the leaves of an M. indica variety grown in Pakistan exerted a strong inhibition of growth of multidrug resistant S. typhi [216]. Antibacterial effects of several mango leaf extracts grown in India have been proven in several bacterial species by Bhatti, 2013 (M. indica variety collected from Rewa district, Madhya Pradesh) [217], Chandrashekar et al. 2014 (mango variety collected from Bhopal, Madhya Pradesh) [218], Madduluri et al., 2013 (collected from Andhra Pradesh) [219], and Sharwat et al., 2013 (collected from Meerut region) [220]. Bhatti, 2013
found that hexane and hexane/ethyl acetate extracts of leaves exert promising antibacterial effects against Mycobacterium tuberculosis, Enterobacter aerogenes, and S. pyogenes. Chandrashekhar et al. 2014 reported that ethanolic extract of leaves can inhibit the growth of Streptococcus mutans. Methanolic and ethanolic extracts of leaves of M. indica were subjected to antibacterial studies against E. coli, klebsiella pneumoniae, Salmonella typhimurium, S. aureus, and B. cereus in the study conducted by Madduluri et al. 2013. They observed strong inhibitory effects by methanolic and ethanolic extracts against B. cereus. Sharwat et al. 2013 found that methanol, ethanol, and benzene extracts of M. indica leaves can effectively inhibit the growth of Pseudomonas fluorescens. Furthermore, antibacterial effects of ethanolic and methanolic extracts of mango seeds have been subjected to antibacterial effects by Awad El-Gied et al. 2012 [221]. 25 different bacterial strains have been used in this study and out of the 25 strains, Mycobacterium smegmatis showed highest inhibition after exposure to ethanolic and methanolic extracts. Antibacterial effects of mango sap have been determined by Negi et al. 2002 [222]. Aqueous and nonaqueous phases of mango sap obtained from four M. indica varieties (Mallika, Totapuri, Rasputi, and Seedling) have been evaluated for antibacterial activity against S. aureus, E. coli, B. cereus, and P. aeruginosa and the nonaqueous phase of all four M. indica varieties was found to be more inhibitory against B. cereus, whereas aqueous extracts showed no inhibitory effects. A study carried out with pet ether, ethyl acetate, alcohol, and water extracts of roots of the an M. indica variety collected from Karnataka, India, by Latha et al. 2011 [223] has proven antibacterial effects. Ethanol extract of roots of studied M. indica variety was found to be more inhibitory against B. subtilis, E. coli, and K. pneumoniae. Silver nanoparticles (loaded onto nonwoven fabrics) prepared from aqueous extract of mango peel have been subjected to antibacterial effects by Yang and Li, 2013 [224]. The results of this study revealed that prepared nanoparticles can effectively inhibit the growth of E. coli, S. aureus, and B. subtilis. A decoction prepared from ripe and unripe mango peel and seeds has been used to study antibacterial effects by Rakholiya et al. 2013 [225]. Among twenty bacterial species used in this study, Micrococcus flavus was found to be more susceptible to the decoctions prepared from ripe seeds, ripe peel, and unripe seeds. In vitro antibacterial effects of four extracts (aqueous, ethanol, methanol, and acetone) prepared from mango flowers have been studied by Verma et al. 2015 [226] against six pathogenic bacterial strains and methanolic and ethanolic extracts of flowers have shown highest inhibition against S. typhi. Singh et al. 2015 [51] have shown antibacterial effects of bark of a mango variety found in India. Hexane and methanol extracts obtained from Sosxhlet extraction of bark have exerted promising antibacterial effects against B. subtilis, S. typhii, P. aeruginosa, E. coli, and S. aureus. Results of antibacterial assays have shown that hexane extract was more active against tested bacterial species. Antibacterial potential of aqueous extract of mango bark has also been carried out by Chidiozie et al. 2014 [227]. E. coli, P. aeruginosa, Proteus vulgaris, Streptococcus faecalis, S. typhii, and Shigella have been included in this and results of this study have illustrated that aqueous extract of mango bark was inhibitory to all bacterial species tested except S. facialis.

5.7. Antifungal Effects of M. indica. Fungal diseases have been identified as an important health problem nowadays [228]. Candida, Aspergillus, and Cryptococcus species are known to cause many fungal diseases worldwide [228]. Candida albicans is reported to be the most common pathogen in fungal infections [229]. Although fungal infections are common, few antifungal drugs are currently used to treat infections [230]. Therefore, the identification of novel drugs as antifungal agents is necessary. Plant-based treatments and natural compounds derived from plants have been identified as ideal drug leads for fungal diseases. A number of pharmacological investigations have confirmed antifungal effects of organic/aqueous extracts of different parts of M. indica. A study was conducted by Muazu et al. 2017 [231] to find antifungal effects of ethanol extract of leaves of an M. indica variety collected in Nigeria. Both extracts tested have shown moderate antifungal effects against Fusarium oxysporum, Fusarium avenaceum, and Pythium aphanidermatum. Moreover, Islam et al. 2010 [176] have evaluated antifungal effects of an ethanolic extract of the leaves of M. indica against three fungal species namely Aspergillus ochraceus, Aspergillus niger, and Aspergillus ustus. Moderate antifungal activity against studied three fungal species has been reported in this study. Antifungal effects of an aqueous extract of leaves of an M. indica variety found in Mexico have been evaluated by Bautista Banos et al. 2002 [232] and results showed a moderate inhibition of fungal strain Colletotrichum gloeosporioides by the aqueous extract. A recent study conducted with seed extracts of four M. indica varieties (Keitt, Sensation, Gomera-3, and peel) found in Spain showed that the extracts inhibited growth of all 18-fungal species tested [233]. Among these species Candida parapsilosis, Candida glabrata, and Lodderomyces elongisporus have exhibited a higher sensitivity towards tested extracts. However, authors have not included the extraction method and type of extracts used to determine antifungal effects. Mango kernel has also been reported to possess antifungal effects. A study carried out by Mutua et al. 2017 [209] has reported methanolic kernel extracts of four mango varieties grown in Kenya (Apple, Ngowe, Sabine, and Kent) exert inhibitory effects against C. albicans. Extracts of Apple, Ngowe, and Sabine showed more inhibitory effects than Kent against C. albicans. Antifungal effects of M. indica bark have also been included in previously mentioned studies [231, 232]. Moderate antifungal activity has been reported for ethanol and methanol extracts [231] and aqueous extract [232] of M. indica bark.

5.8. Anthelmintic Effects of M. indica. Helminth infections which are caused by parasitic worms are commonly seen in tropical regions [234]. They live either as parasites or in some cases in a free-living form [234]. Intestinal nematodes (IN) or soil-transmitted helminths (STH) are the most common types of nematodes [235]. It has been estimated that approximately 30% of world population is primarily infected with helminth parasites annually [236]. Development of resistance to helmint parasites has become a major problem in the
treatment of the helminth infections [236]. Hence, discovery of natural remedies that can target helminth infections is important. Anthelmintic effects of extracts of different parts of M. indica have been studied in several in vitro studies. Anthelmintic effects of petroleum ether, ethyl acetate, and ethanol extracts of roots of two M. indica varieties (M. indica L. Var. Thotapuri and M. indica L. Var. Neelam) collected from Karnataka, India, were investigated by Latha et al. 2012 [237]. They showed dose-dependent anthelmintic effects of all three extracts of the two mango varieties used against earthworm Phereutina posthuma with a higher activity for M. indica L. Var. Thotapuri than for M. indica L. Var. Neelam. Sujon et al. 2008 [238] have evaluated anthelmintic effects of an ethanolic extract of roots of an M. indica variety collected from Bangladesh. Moderate anthelmintic effects were seen against adult nematodes collected from the gastrointestinal tract of goats. Anthelmintic effects of aqueous extract of mango fruit against intestinal nematode Strongyloides stercoralis have been studied by El-Sherbini and Osman, 2013 [239]. Aqueous extract of M. indica fruits have shown 100% inhibition of S. stercoralis larval development. A study carried out by Garcia et al. 2003 [240] demonstrated anthelmintic effects of an aqueous extract of bark of M. indica in Trichinella spiralis where significant reduction in parasite larvae and a reduction of serum specific antitrichinella IgE were reported.

5.9. Antiplasmodial Effects of M. indica. Complete eradication of malaria appears to be a major challenge in the world due to the development of resistance to antimalarial drugs [241]. Many parasites in genus Plasmodium cause malaria and Plasmodium falciparum is the most predominant in genus Plasmodium [242]. It has been estimated that malaria affects approximately 280–290 million people annually [242]. Quinine and artemisinin are naturally derived antimalarial drugs, which have been used for almost 400 years in the treatment of malaria [243]. However, P. falciparum has developed complete resistance to almost all the antimalarial drugs in clinical use [243]. Therefore, it is of paramount importance to investigate novel treatment methods/drugs which can target the malaria parasites. Despite latest inventions of new drugs by pharmaceutical companies, medicinal plants have gained much interest as novel sources for antimalarial drugs. Studies with antiplasmodial effects of mango are limited in literature. A study carried out by Awe et al. 1998 [244] has shown antiplasmodial effects of a bark methanol extract of a mango variety collected from Nigeria. The methanol extract has exhibited significant antiplasmodial effects against malaria parasite, Plasmodium yoelii nigeriensis. Ziriihi et al. 2005 [245] have also shown some mild inhibitory effects of an ethanolic extract of mango bark collected from Ivory Coast on P. falciparum. Bidla et al. 2004 [246], on the other hand, have shown that methanol/chloroform extract of leaves of a mango variety collected from India possesses moderate antiplasmodial effects in P. falciparum.

5.10. Antihyperlipemic Effects of M. indica. Hyperlipidemia is considered as a major reason for atherosclerosis and coronary heart disease [247]. Coronary heart disease is the main cause of death in the world [247]. Scientific investigation of herbal remedies for antihyperlipemic effects will give a strong support for the development of drugs for hyperlipidemia. A recent study by Gururaja et al., 2017 [248], reported cholesterol lowering effects of a methanolic extract of M. indica leaves in albino Wistar rats. A significant decrease in plasma cholesterol levels has been observed in rats administrated with cholesterol in this study. Results of the studies conducted with aqueous extracts [249, 250] and ethanolic extracts [251, 252] of M. indica leaves have shown promising antihyperlipemic effects in hyperlipemic rat models. Another study conducted by Vasant and Narasimhacharya, 2011 [253], has reported that feeding of mango fruit powder to hyperlipemic rats can significantly reduce serum cholesterol levels, very low-density lipoproteins (VLDL), and triglycerides (TG). A study conducted by Dineshkumar et al. 2010 [254] with 828 type 2 diabetes patients with high serum cholesterol levels, living in Gopali, India, has shown that consumption of aqueous extract of mango bark can significantly reduce serum total cholesterol level.

5.11. Antidiabetic Effects of M. indica. Diabetes mellitus is a metabolic disease resulting from a defect in insulin action or secretion [255]. It has now become a major health problem affecting 442 million people worldwide [256]. 90% of diabetes cases are type 2 and the remainder is type 1 [257]. Blood glucose homeostasis is the key to prevent diabetes associated complications such as cardiovascular diseases, kidney diseases, eye problems, and peripheral neuropathy [258]. Several plant-based remedies have been used to treat type 2 diabetes in traditional medicine and a number of pharmacological studies have been conducted to validate these claims [259, 260]. Fruit peel, flesh, seed kernel, leaves, and bark of M. indica have been extensively studied for their antidiabetic properties. Gondi and Prasada Rao, 2015 [261] have showed that an ethanolic extract of mango fruit peel can successfully reduce blood glucose level in streptozotocin-induced diabetic rats. Significant decrease in fructosamine and glycated hemoglobin, which are considered as status indicators of diabetes, has also been observed after treatment with the ethanolic extract of mango peel. Another study carried out by Gondi et al. 2015 [262] with M. indica fruit peel powder showed a significant reduction of blood glucose level and diabetes associated complications in rats. Similar results have been obtained in a study carried with a flour prepared from mango fruit pulp [263]. Irdoni et al., 2016 [264], showed that flour supplement prepared with mango kernel effectively reduced blood glucose level in diabetes rats. Improvement in liver function, blood glucose level, hepatic glycogen, lipid profile, and hepatic and pancreatic malonaldehyde was observed in diabetic rats supplied with flour supplement.

Several studies on antidiabetic effects of M. indica leaves have been conducted. Antidiabetic efficacy of methanolic leaf extracts of young and matured leaves of M. indica has been evaluated by Mohammed and Rizvi, 2017 [265]. In this study authors found that young leaves were more effective than matured leaves as antidiabetic. Evaluation of antidiabetic effects, by determining inhibition rates of yeast, rat alpha-glucosidase, and porcine pancreatic alpha-amylase, has shown that ethanolic leaf extracts (Thai and Indian
Table 2: Some common phytochemicals isolated from *M. indica* and their reported biological activities.

| Reported pharmacological effects of pure compounds/crude extracts of *M. indica* | Compounds responsible for reported pharmacological activity | Part(s) used to isolate |
|---|---|---|
| Cytotoxic and apoptotic effects [53–56, 99–116] | 29-Hydroxy mangiferonic acid | Bark [117], resin [59] |
| | 3,4-dihydroxybenzoic acid (protocatechuic acid) | Bark [118], fruit peel [30] |
| | Catechin | Bark [118] and leaves [119] |
| | Elemene | Flower [60], leaves [60], and bark [120] |
| | Epigallocatechin gallate | Leaves [119], bark [121] |
| | Ethyl gallate | Flower [60] |
| | Friedelin | Bark [59, 60] |
| | Gallic acid | Seed [122], bark [118] |
| | Humulene | Leaf and flower [60] |
| | Kaempferol | Fruit [56–58] |
| | Linalool | Flowers [60], leaves [60], and fruits [123] |
| | Mangiferin | Bark, leaves, and fruit [17, 54, 55] |
| | Methyl gallate | Flower [60] |
| | Mono(2-ethylhexyl) ester | Bark [51] |
| | N-octyl gallate | Flower [60] |
| | N-propyl gallate | Flower [60] |
| | Quercetin | Bark [113–115], fruit [113–115], and leaves [113–115] |
| | β-carotene | Fruit [61] |
| | 5-(11`Z-Heptadecenyl)-resorcinol and 5-(8`Z,11`Z-heptadecadienyl)-resorcinol | Fruit [124] |
| | Epigallocatechin gallate | Leaves [119], bark [121] |
| | Friedelin | Bark [59, 60] |
| | Gallic acid | Seed [122], bark [118] |
| | Humulene | Leaf and flower [60] |
| | Kaempferol | Fruit [56–58] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | Shikimic acid | Bark [61], fruit [129] |
| Anti-inflammatory effects [53–56, 112, 124–128] | 3,4-Dihydroxy benzoic acid (protocatechuic acid) | Bark [118], fruit peel [30] |
| | Catechin | Bark [118] and leaves [119] |
| | Ethyl gallate | Flower [60] |
| | Gallic acid | Seed [122], bark [118] |
| | Kaempferol | Fruit [56–58] |
| | Linalool | Flowers [60], leaves [60], fruits [123] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | Methyl gallate | Flower [60] |
| | N-octyl gallate | Flower [60] |
| | N-propyl gallate | Flower [60] |
| | Quercetin | Bark [113–115], fruit [113–115] and leaves [113–115] |
| | Shikimic acid | Bark [61], fruit [135] |
| | β-carotene | Fruit [61] |
| Antioxidant effects [53–56, 104, 106, 130–134] | | |
Table 2: Continued.

| Reported pharmacological effects of pure compounds/ crude extracts of *M. indica* | Compounds responsible for reported pharmacological activity | Part(s) used to isolate |
|---|---|---|
| **Antibacterial effects** [51, 53–56, 106, 113–115, 118, 136–142] | 3,4-Dihydroxy benzoic acid (Protocatechuic acid) | Bark [118], fruit peel [30] |
| | 3-Chloro-N-(2-phenylethyl) propanamide | Bark [51] |
| | 9,12-Tetradecadiene-1-ol-acetate | Bark [118] |
| | Benzoic acid | Bark [118] and leaves [119] |
| | Catechin | Seed [122] bark [118] |
| | Gallic acid | Fruit [56–58] |
| | Kaempferol | Flowers [60], leaves [60], fruits [139] |
| | Linalool | Bark, leaves, fruit [17, 54, 55] |
| | Mangiferin | Flower [60] |
| | Methyl gallate | Flower [60] |
| | N-Heneicosane | Flower [60] |
| | N-Propylgallate | Bark [113–115], fruit [113–115] and leaves [113–115] |
| | Quercetin | Flower [60] |

| **Antifungal effects** [113–115, 143–147] | Benzoic acid | Bark [118] |
| | Catechin | Bark [118] and leaves [119] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | Nerol | Leaf and flower [60] |
| | N-Pentylgallate | Flower [60] |
| | N-Propylgallate | Flower [60] |
| | Quercetin | Bark [113–115], fruit [113–115] and leaves [113–115] |

| **Antiviral effects** [54, 55, 148–151] | Catechin | Bark [118] and leaves [119] |
| | Isomangiferin | Bark [60] and leaves [152] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | Methyl gallate | Flower [60] |
| | N-Pentylgallate | Flower [60] |

| **Antidiabetic effects** [54–58, 106, 153] | 3,4-Dihydroxy benzoic acid (Protocatechuic acid) | Bark [118], fruit peel [30] |
| | Gallic acid | Seed [122] bark [118] |
| | Kaempferol | Fruit [56–58] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |

| **Antimalarial activity** [51, 54, 55] | 3-Chloro-N-(2-phenylethyl) propanamide | Bark [51] |
| | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | Epigallocatechin gallate | Leaves [119], bark [121] |
| | Friedelin | Bark [59, 60] |
| | Gallic acid | Seed [122] bark [118] |
| | Mono(2-ethylhexyl) ester | Bark [51] |
| | Quercetin | Bark [113–115], fruit [113–115] and leaves [113–115] |
| | β-carotene | Fruit [61] |

| **Antiobesity activities** [53, 106, 113–116, 154–156] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | β-carotene | Fruit [61] |

| **Immunomodulatory** [54, 55, 116] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| | β-carotene | Fruit [61] |
### Table 2: Continued.

| Reported pharmacological effects of pure compounds/ crude extracts of *M. indica* | Compounds responsible for reported pharmacological activity | Part(s) used to isolate |
|---|---|---|
| Neuroprotective/analgesic effects/aphrodisiac effects/analgesic [54, 55, 113–115, 126, 157–159] | Friedelin | Bark [59, 60] |
|  | Linalool | Flowers [60], leaves [60], fruits [139] |
|  | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
|  | Nerol | Leaf and flower [60] |
|  | Quercetin | Bark [113–115], fruit [113–115] and leaves [113–115] |
|  | Ocimene | Flower and leaves [60, 61] |
| Effects on PC12 tyrosine kinase activity [160] | Catechin | Bark [118] and leaves [119] |
| Antifibrotic effects [161] | Elemene | Flower [60], leaves [60] and bark [120] |
| Hemolytic activity [104] | Ethyl gallate | Flower [60] |
| Antipyretic activity [126] | Friedelin | Bark [59, 60] |
| Anthelmintic effects [54, 55] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| Cardioprotective [54, 55] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| Antiamoebic [54, 55] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| Bronchodilatory effects [54, 55] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| Lipolytic effects [54, 55] | Mangiferin | Bark, leaves, fruit [17, 54, 55] |
| Effects on cytoplasmic maturation of oocytes [162] | Mono(2-ethylhexyl)ester | Bark [51] |
| Inhibitive effects on hyaluronidase and collagenase [163] | N-Octyl gallate | Flower [60] |
| Nematicidal activity [164] | Ocimene | Flower and leaves [60, 61] |
| Effects on blood pressure [53, 113–115] | Quercetin | Bark [113–115], fruit [113–115] and leaves [113–115] |
| Anticoagulant/antithrombotic [165] | Shikimic acid | Bark [61], fruit [129] |

mango) have antidiabetic effects [200, 266]. Aderibigbe et al. 1999 [267] found that aqueous extract of *M. indica* leaves can significantly reduce blood glucose level in streptozotocin-induced diabetic rats. Tanko et al. 2012 [268], Mangola, 1990 [269], Miura et al., 2001 [270], and Waheed et al., 2006 [271], have also proven hypoglycemic effect of aqueous extract of *M. indica* leaves in diabetic rats. Sharma et al., 1997 [272], have demonstrated hypoglycemic potential of ethanolic extract of mango leaves in normal and streptozotocin-induced diabetic rats. They have successfully shown significant antihyperglycaemic effects in diabetic rats when supplied with ethanolic extract of mango leaves in normal and streptozotocin-induced diabetic rats. They have also proven hypoglycemic potential of ethanolic extract of mango leaves in normal and streptozotocin-induced diabetic rats. They have successfully shown significant antihyperglycaemic effects in diabetic rats when supplied with ethanolic extract of *M. indica* leaves. A study conducted by Lima et al. 2006 [277] found that a decoction prepared from *M. indica* flowers can significantly increase gastroprotective properties in an experimental rat model by reducing gastric juice volume and acidity. Furthermore, Severi et al. 2009 [278] have shown that a decoction prepared from leaves of *M. indica* reduces gastric lesions induced by HCl, ethanol, and nonsteroidal anti-inflammatory drugs in experimental rat models. Antiulcer potential of ethanol and petroleum ether extracts prepared from mango leaves has also been reported by Neelima et al. 2012 [279]. Akindele et al. 2012 [280] who assessed gastroprotective effects of a drug formulation (DAS-77) which comprises *M. indica* bark and papaya roots showed a significant reduction of gastric ulcers after feeding with DAS-77 in rat models. Antiulcer activity of an ethanolic extract of mango kernels and in combination with vitamin C, ZnSO₄, and menadione in pylorus ligation and ethanol-induced ulcers in rat models was evaluated by Nethravathi K et al. 2015 [281]. Considerable reduction in gastric volume, ulcer score and index, and total acid output was observed after administration of ethanolic extract and the above drug combinations.

There is a good agreement that exists between pharmacological properties of crude extracts of different parts of
M. indica and biological effects of pure compounds isolated from M. indica. Common compounds found in various parts (bark, leaves, and fruits) of M. indica such as mangiferin, derivatives of mangiferin, gallic acid, catechin, quercetin, β-carotene, shikimic acid, and kaempferol have been reported to possess antioxidant effects in several in vitro and in vivo studies [54–58, 61, 62]. Studies that have shown antioxidant effects of crude extracts of M. indica, [73–83], further suggest a striking correlation for the presence of these antioxidant compounds in those tested extracts. Catechin, mangiferin, gallic acid, epigallocatechin gallate, friedelin, humulene, kaempferol, and quercetin are well-known reported anticancer compounds present in mango [54–58, 61, 62]. Available studies that show anticancer effects of different crude extracts (leaves, bark, and fruits), [190–202], strongly correlate the presence of these compounds in crude extracts of M. indica. Alkylresorcinols, epigallocatechin gallate, mangiferin, friedelin, gallic acid, and quercetin have been reported to possess anti-inflammatory effects in various in vitro and in vivo studies [54–58, 61, 62]. Occurrence of these anti-inflammatory compounds in M. indica has been well-documented and reported pharmacological studies which illustrate anti-inflammatory effects [88–98, 166–174] of M. indica’s crude extracts strongly correlate pharmacological effects and chemical composition. Apart from the abovementioned compounds, a large number of chemical compounds have been isolated and reported from different parts (fruits, bark, leaves, flowers, and roots) of M. indica. Some major compounds isolated or identified by gas chromatography–mass spectrometry (GC-MS) and liquid chromatography–mass spectrometry (LC-MS) from different parts of mango tree and reported biological effects of those pure compounds have been listed in Table 2. According to the information present in Table 2, it is clear that common mango compounds such as mangiferin, quercetin, catechin, and kaempferol possess a wide range of pharmacological properties.

**Conflicts of Interest**

The authors have no conflicts of interest.

**References**

[1] R. Hirano, T. H. Oo, and K. N. Watanabe, “Myanmar mango landraces reveal genetic uniqueness over common cultivars from Florida, India, and Southeast Asia,” Genome, vol. 53, no. 4, pp. 321–330, 2010.

[2] V. G. Sa´uco, “Mango production and world market: Current situation and future prospects,” Acta Horticulturae, vol. 645, pp. 107–116, 2004.

[3] C. Torres-León, R. Rojas, J. C. Contreras-Esquível, L. Serna-Cock, R. E. Belmares-Cerda, and C. N. Aguilar, “Mango seed: Functional and nutritional properties,” Trends in Food Science & Technology, vol. 55, pp. 109–117, 2016.

[4] P. V. R. Reddy and K. Sreedevi, “Arthropod communities associated with mango (Mangifera indica L.): diversity and interactions,” in Economic and Ecological Significance of Arthropods in Diversified Ecosystems, pp. 271–298, Springer, Singapore.

[5] J. Ghuniyal, “Ethnomedical, chemical, pharmacological, toxicological properties of mangiferia indica: a review,” International Journal of Pharma Research & Review, vol. 4, no. 10, pp. 51–64, 2015.

[6] M. Siddiq, S. Akhtar, and R. Siddiq, “Mango processing, products and nutrition,” Tropical and Subtropical Fruits: Postharvest Physiology, Processing and Packaging, pp. 277–297, 2012.

[7] C. M. Ajila, S. G. Bhat, and U. J. S. P. Rao, “Valuable components of raw and ripe peels from two Indian mango varieties,” Food Chemistry, vol. 102, no. 4, pp. 1006–1011, 2007.

[8] I. Ignat, I. Volf, and V. I. Popa, “A critical review of methods for characterisation of polyphenolic compounds in fruits and vegetables,” Food Chemistry, vol. 126, no. 4, pp. 1821–1835, 2011.

[9] S. K. Mukherjee, “The mango-its botany, cultivation, uses and future improvement, especially as observed in india,” Economic Botany, vol. 7, no. 2, pp. 130–162, 1953.

[10] S. K. Mukherjee, “Origin of mango (Mangifera indica),” Economic Botany, vol. 26, no. 3, pp. 260–264, 1972.

[11] B. Slippers, G. I. Johnson, P. W. Crous, T. A. Coutinho, B. D. Wingfield, and M. J. Wingfield, “Phylogenetic and morphological re-evaluation of the Botryosphaeria species causing diseases of Mangifera indica,” Mycologia, vol. 97, no. 1, pp. 99–110, 2005.

[12] R. E. Litz, The Mango: Botany, Production And Uses, CABI, 2009.

[13] D. Nandwani, “Grafting of mango cultivars (Mangifera indica L.) in the u.s. virgin islands,” Their Culture, Environment, and Use, pp. 441–461, 2006.

[14] A. Nurul Huda, M. R. Che Salhah, A. Abu Hassan, A. Hamdan, and M. N. Abdul Razak, “Pollination services of mango flower pollinators,” Journal of Insect Science, vol. 15, no. 1, article no. i13, 2015.

[15] D. Sivakumar, Y. Jiang, and E. M. Yahia, “Maintaining mango (Mangifera indica L.) fruit quality during the export chain,” Food Research International, vol. 44, no. 5, pp. 1254–1263, 2011.

[16] G. M. M. Parvez, “Pharmacological activities of mango (Mangifera Indica): A review,” Journal of Pharmacognosy and Phytochemistry, vol. 3, 1 page, 2016.

[17] N. Wauthoz, A. Balde, E. S. d. Balde, M. Van Damme, and P. Wingfield, and M. J. Wingfield, “Phylogenetic and morphological Botany,” in Economic and Ecological Significance of Arthropods in Plants, vol.1, pp. 44–46, 2016.

[18] E. Bekoe, I. Kretchy, J. Sarkodie et al., “Ethnomedicinal survey of plants used for the management of hypertension sold in the makola market, Accra, Ghana,” European Journal of Medicinal Plants, vol. 20, no. 3, pp. 1–9, 2017.

[19] C. P. Khare, Indian Medicinal Plants: An Illustrated Dictionary, Springer Science & Business Media, 2008.

[20] C. Williams, “Medicinal Plants in Australia: Plants, Poisons and Potions,” vol. 3, p. 226, Rosenberg Publishing, 2002.

[21] S. S. Tirtha, “The Ayurveda Encyclopedia,” in Natural Secrets to Healing, Prevention, and Longevity, Sat Yuga Press, 2007.

[22] T. Aagarwal, G. Kochar, and S. Geol, “Impact of iron supplementation on anemia during pregnancy,” Age, vol. 4500, no. 7000, 10 pages, 2008.

[23] M. S. Khandare, “Mango (Mangifera indica Linn) A medicinal and holy plant,” Journal of Medicinal Plants Studies, vol. 4, no. 4, pp. 44–46, 2016.

[24] E. U. Etuk, S. O. Bello, S. A. Isezuo, and B. J. Mohammed, “Ethnobotanical survey of medicinal plants used for the treatment of Diabetes mellitus in the north western region of Nigeria,” Asian
**Evidence-Based Complementary and Alternative Medicine**

16

A. C. Ene and S. E. Atawodi, "Ethemnodicmic survey of plants used by the Kanuris of North-eastern Nigeria," *Indian Journal of Traditional Knowledge*, vol. 11, no. 4, pp. 640–645, 2012.

A. H. Memon, F. M. A. Rind, M. G. H. Laghari et al., "Common folk medicinal and ethnomedicinal uses of thirty medicinal plants of districts Dadu and Jamshoro, Sindh, Pakistan," *Sindh University Research Journal (Science Series)*, vol. 40, no. 2, pp. 89–108, 2008.

M. F. Nisar, S. Ismail, M. Arshad, A. Majeed, and M. Arfan, "Ethnomedicinal floras of District MandiBahaudin, Pakistan," *Middle-East Journal of Scientific Research*, vol. 9, no. 2, pp. 233–238, 2011.

R. W. Bussmann and D. Sharon, "Traditional medicinal plant use in Northern Peru: Tracking two thousand years of healing culture," *Journal of Ethnobiology and Ethnomedicine*, vol. 2, article no. 47, 2006.

D. M. A. Jayaweera, *Medicinal plants (Indigenous and exotic) used in Ceylon*, National Science Council of Sri Lanka, 1980.

J. C. Barreto, M. T. S. Trevisan, W. E. Hull et al., "Characterization and quantitation of polyphenolic compounds in bark, kernel, leaves, and peel of mango (*Mangifera indica L.*)," *Journal of Agricultural and Food Chemistry*, vol. 56, no. 14, pp. 5599–5610, 2008.

N. Berardini, R. Fezer, J. Conrad, U. Beifuss, R. Carl, and A. Schieber, "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*, vol. 53, no. 5, pp. 1563–1570, 2005.

V. Nayan, S. K. Oneteru, and D. Singh, "Mangifera indica flower extract mediated biogenic green gold nanoparticles: Efficient nanocatalyst for reduction of 4-nitrophenol," *Environmental Progress & Sustainable Energy*, 2017.

H. Ichiki, T. Miura, M. Kubo et al., "New antidiabetic compounds, mangiferin and its glucoside," *Biological & Pharmaceutical Bulletin*, vol. 21, no. 12, pp. 1389–1390, 1998.

X. Ma, H. Wu, L. Liu et al., "Polyphenolic compounds and antioxidant properties in mango fruits," *Scientia Horticulturae*, vol. 129, no. 1, pp. 102–107, 2011.

I. E. Dreosti, "Antioxidant polyphenols in tea, cocoa, and wine," *Nutrition Journal*, vol. 16, no. 7-8, pp. 692–694, 2000.

S. M. Rocha Ribeiro, J. H. De Queiroz, M. E. Lopes Ribeiro de Queiroz, F. M. Campos, and H. M. Pinheiro Sant’Ana, "Antioxidant in mango (*Mangifera indica L.*) pulp," *Plant Foods for Human Nutrition*, vol. 62, no. 1, pp. 13–17, 2007.

M. Martin and Q. He, "Mango bioactive compounds and related nutraceutical properties—A review," *Food Reviews International*, vol. 25, no. 4, pp. 346–370, 2009.

I. C. W. Arts, B. Van De Putte, and P. C. H. Holfman, "Catechin contents of foods commonly consumed in The Netherlands. I. Fruits, vegetables, staple foods, and processed foods," *Journal of Agricultural and Food Chemistry*, vol. 48, no. 5, pp. 1746–1751, 2000.

F. Delgado-Vargas, A. R. Jiménez, and O. Paredes-López, "Natural pigments: carotenoids, anthocyanins, and betalains—characteristics, biosynthesis, processing, and stability," *Critical Reviews in Food Science and Nutrition*, vol. 40, no. 3, pp. 173–289, 2000.

A. A. Woodall, S. W.-M. Lee, R. J. Weesie, M. J. Jackson, and G. Britton, "Oxidation of carotenoids by free radicals: Relationship between structure and reactivity," *Biochimica et Biophysica Acta (BBA) - General Subjects*, vol. 1336, no. 1, pp. 33–42, 1997.

A. M. Gil, I. F. Duarte, I. Delgadillo et al., "Study of the compositional changes of mango during ripening by use of nuclear magnetic resonance spectroscopy," *Journal of Agricultural and Food Chemistry*, vol. 48, no. 5, pp. 1524–1536, 2000.

F. B. Jungalwala and H. R. Cama, "Carotenoids in mango (*Mangifera indica*) fruit," *Indian Journal of Chemistry*, vol. 1, no. 1, 36 pages, 1963.

F. Chen, D. Tholl, J. Bohlmann, and E. Pichersky, "The family of terpene synthases in plants: A mid-size family of genes for specialized metabolism that is highly diversified throughout the kingdom," *The Plant Journal*, vol. 66, no. 1, pp. 212–229, 2011.

G. Hernández-Sánchez, I. Sanz-Berzosa, V. Casaña-Giner, and E. Primo-Yúfera, "Attractiveness for Ceratitis capitata (Wiedemann) (Dipt., Tephritidae) of mango (*Mangifera indica* cv. Tommy Atkins) airborne terpenes," *Journal of Applied Entomology*, vol. 125, no. 4, pp. 189–192, 2001.

H. J. D. Lalel, Z. Singh, and S. C. Tan, "Aroma volatiles production during fruit ripening of 'Kensington Pride' mango," *Postharvest Biology and Technology*, vol. 27, no. 3, pp. 323–336, 2003.

G. Ruiz-Montañez, J. A. Ragazzo-Sánchez, M. Calderón-Santoyo, G. Velázquez-De La Cruz, J. A. Ramírez De León, and A. Navarro-Ocaña, "Evaluation of extraction methods for preparative scale isolation of mangiferin and lupeol from mango peels (*Mangifera indica L.*)," *Food Chemistry*, vol. 159, pp. 267–272, 2014.

C. Engels, M. Knödler, Y.-Y. Zhao, R. Carle, M. Gänzle, and A. Schieber, "Antimicrobial activity of gallotannins isolated from mango (*Mangifera indica L.*) kernels," *Journal of Agricultural and Food Chemistry*, vol. 57, no. 17, pp. 7712–7718, 2009.

J. D. J. Ornelas-Paz, E. M. Yahia, and A. Gardea-Bejar, "Identification and quantification of xanthophyll esters, carotenes, and tocopherols in the fruit of seven Mexican mango cultivars by liquid chromatography-atmospheric pressure chemical ionization-time-of-flight mass spectrometry [LC-(APCI-)MS]," *Journal of Agricultural and Food Chemistry*, vol. 55, no. 16, pp. 6628–6635, 2007.

A. Kozubek and J. H. P. Tyman, "Resorcinolic lipids, the natural non-isoprenoid phenolic amphiphiles and their biological activity," *Chemical Reviews*, vol. 99, no. 1, pp. 1–26, 1999.

M. K. Edirweera, K. H. Tennekoon, S. R. Samarakoona, A. Adhikari, I. Thabrew, and E. Dilip de Silva, "Isolation of a new resorcinolic lipid from Mangifera zeylanica Hooke.f. bark and its cytotoxic and apoptotic potential," *Biomedicine & Pharmacotherapy*, vol. 89, pp. 194–200, 2017.

R. Singh, S. K. Singh, R. S. Maharia, and A. N. Garg, "Identification of new phytoconstituents and antimicrobial activity in stem bark of Mangifera indica (L.)," *Journal of Pharmaceutical and Biomedical Analysis*, vol. 105, pp. 150–155, 2015.

M. K. Edirweera, K. H. Tennekoon, A. Adhikari, S. R. Sama- rakoon, I. Thabrew, and E. D. De Silva, "New halogenated constituents from Mangifera zeylanica Hooke.f. and their potential anti-cancer effects in breast and ovarian cancer cells," *Journal of Ethnopharmacology*, vol. 189, pp. 165–174, 2016.

M. Harwood, B. Danielewska-Nikiel, J. F. Borzelleca, G. W. Flamm, G. M. Williams, and T. C. Lines, "A critical review of the data related to the safety of quercetin and lack of evidence of in vivo toxicity, including lack of genotoxic/carcinogenic properties," *Food and Chemical Toxicology*, vol. 45, no. 11, pp. 2179–2205, 2007.
[54] M. Telang, S. Dhubal, A. Mandhare, and H. Hirwani, “Therapeutic and cosmetic applications of mangiferin: A patent review,” Expert Opinion on Therapeutic Patents, vol. 23, no. 12, pp. 1561–1560, 2013.

[55] Jyotshila, P. Khare, and K. Shanker, “Mangiferin: A review of sources and interventions for biological activities,” BioFactors, vol. 42, no. 5, pp. 504–514, 2016.

[56] J. M. Calderón-Montañó, E. Burgos-Morón, C. Pérez-Guerrero, and M. López-Lázaro, “A review on the dietary flavonoid kaempferol,” Mini-Reviews in Medicinal Chemistry, vol. 11, no. 4, pp. 298–344, 2011.

[57] S. M. Ribeiro and A. Schieber, “Bioactive compounds in traditional medicine with antioxidant activity,” Journal of Ethnopharmacology, vol. 51, no. 17, pp. 5006–5011, 2003.

[58] S. M. R. Ribeiro, L. C. A. Barbosa, J. H. Queiroz, M. Knödler, and P. Scartezzini and E. Speroni, “Review on some plants of Indian medicinal plants,” Journal of Ethnopharmacology, vol. 42, no. 5, pp. 504–514, 2016.

[59] R. J. Nijveldt, E. van Nood, D. E. C. van Hoorn, P. G. Boelens, K. van Norren, and P. A. M. van Leeuwen, “Flavonoids: a review of probable mechanisms of action and potential applications,” American Journal of Clinical Nutrition, vol. 74, no. 4, pp. 418–425, 2001.

[60] F. Giampieri, J. M. Alvarez-Suarez, S. Tulpiani et al., “Photo-protective potential of strawberry (Fragaria × ananassa) extract against UV-A irradiation damage on human fibroblasts,” Journal of Agricultural and Food Chemistry, vol. 60, no. 9, pp. 2322–2327, 2012.

[61] P. A. Thambi, S. John, E. Lydia, P. Iyer, and S. J. Sarah Jane Monica, “Antimicrobial efficacy of mango peel powder and formulation of recipes using mango peel powder (Mangifera indica L.),” International Journal of Home Science, vol. 2, pp. 155–161, 2016.

[62] A. M. Abbasi, F. Liu, X. Guo, X. Fu, T. Li, and R. H. Liu, “Phytochemical composition, cellular antioxidant capacity and anti-proliferative activity in mango (Mangifera indica L.) pulp and peel,” International Journal of Food Science & Technology, vol. 52, no. 3, pp. 817–826, 2017.

[63] B. Sultana, Z. Hussain, M. Asif, and A. Munir, “Investigation on the antioxidant activity of leaves, peels, stems, bark, and kernel of Mango (Mangifera indica L.),” Journal of Food Science, vol. 77, no. 8, pp. C849–C852, 2012.

[64] H. Kim, J. Y. Moon, H. Kim et al., “Antioxidant and antiproliferative activities of mango (Mangifera indica L.) flesh and peel,” Food Chemistry, vol. 121, no. 2, pp. 429–436, 2010.

[65] E. Dotta, M. G. Lobo, and M. Gonzalez, “Reutilization of mango byproducts: study of the effect of extraction solvent and temperature on their antioxidant properties,” Journal of Food Science, vol. 77, no. 1, pp. C80–C88, 2012.

[66] A. Septembre-Malaterre, G. Stanislas, E. Douraguia, and M.-P. Gonthier,” Evaluation of nutritional and antioxidant properties of the tropical fruits banana, litchi, mango, papaya, passion fruit and pineapple cultivated in Réunion French Island,” Food Chemistry, vol. 212, pp. 225–233, 2016.

[67] K. Afiña, M. Kamruzzaman, I. Mahfuza, H. Afzal, H. Arzina, and H. Roksana, “A comparison with antioxidant and functional properties among five mango (Mangifera indica L.) varieties in Bangladesh,” International Food Research Journal, vol. 21, no. 4, pp. 1501–1506, 2014.

[68] G. S. El-Baroty, M. F. Khalil, and S. H. A. Mostafa, “Natural antioxidant ingredient from by-products of fruits,” American Journal of Agricultural and Biological Sciences, vol. 9, no. 3, pp. 311–320, 2014.

[69] S. Norshazila, I. S. Zahir, K. M. Suleiman, M. R. Aisyah, and K. K. Rahim, “Antioxidant levels and activities of selected seeds of Malaysian tropical fruits,” Malaysian Journal of Nutrition, vol. 16, no. 1, pp. 149–159, 2010.

[70] M. Pitchaon, “Antioxidant capacity of extracts and fractions from mango (Mangifera indica Linn.) seed kernels,” International Food Research Journal, vol. 18, no. 2, pp. 523–528, 2011.

[71] C. G. Mohan, M. Deepak, G. L. Viswanatha et al., “Anti-oxidant and anti-inflammatory activity of leaf extracts and fractions of Mangifera indica,” Asian Pacific Journal of Tropical Medicine, vol. 6, no. 4, pp. 311–314, 2013.

[72] A. A. Beg and A. S. Baldwin, “The I kappa B proteins: multi-functional regulators of Rel/NF-kappa B transcription factors,” Genes & Development, vol. 7, no. II, pp. 2064–2070, 1993.
Evidence-Based Complementary and Alternative Medicine

[85] F. Mercurio, H. Zhu, B. W. Murray et al., "IKK-1 and IKK-2: cytokine-activated IkB kinases essential for NF-κB activation," *Science*, vol. 278, no. 5339, pp. 860–866, 1997.

[86] S. Schreiber, S. Nikolaus, and J. Hampe, "Activation of nuclear factor κB inflammatory bowel disease," *Gut*, vol. 42, no. 4, pp. 477–484, 1998.

[87] S. H. Itzkowitz and X. Yao, "Inflammation and cancer, IV. Colorectal cancer in inflammatory bowel disease: the role of inflammation," *American Journal of Physiology-Gastrointestinal and Liver Physiology*, vol. 287, no. 1, pp. G7–G17, 2004.

[88] H. Kim, N. Banerjee, R. C. Barnes et al., "Mango polyphenolics reduce inflammation in intestinal colitis-involvement of the mIR-126/P13K/AKT/mTOR axis in vitro and in vivo," *Molecular Carcinogenesis*, vol. 56, no. 1, pp. 197–207, 2016.

[89] H. Kim, N. Banerjee, I. Ivanov 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*, vol. 60, no. 9, pp. 1912–1923, 2016.

[90] L. Márquez, B. G. Pérez-Nievas, I. Gárate et al., "Anti-inflammatory effects of Mangifera indica L. extract in a model of colitis," *World Journal of Gastroenterology*, vol. 16, no. 39, pp. 4922–4930, 2010.

[91] Y. Jiang, X.-Y. You, K.-L. Fu, and W.-L. Yin, "Effects of extract from Mangifera indica leaf on monosodium urate crystal-induced gouty arthritis in rats," *Evidence-Based Complementary and Alternative Medicine*, vol. 2012, Article ID 967573, 6 pages, 2012.

[92] G. Garrido, D. González, Y. Lemus et al., "In vivo and in vitro anti-inflammatory activity of Mangifera indica L. extract (VIMANG)," *Pharmaceutical Research*, vol. 50, no. 2, pp. 143–149, 2004.

[93] G. Garrido, D. Gonzalez, C. Delport et al., "Analgescic and anti-inflammatory effects of Mangifera indica L. extract (Vimang)," *Phytotherapy Research*, vol. 15, no. 1, pp. 18–21, 2001.

[94] G. Garrido, R. Delgado, Y. Lemus, J. Rodriguez, D. García, and A. J. Núñez-Sellés, "Protection against septic shock and suppression of tumor necrosis factor alpha and nitric oxide production on macrophages and microglia by a standard aqueous extract of Mangifera indica L. (VIMANG): role of mangiferin isolated from the extract," *Pharmacological Research*, vol. 50, no. 2, pp. 165–172, 2004.

[95] G. Martinez, R. Delgado, G. Prez, G. Garrido, A. J. Nez Sells, and O. S. Len, "Evaluation of the in vitro antioxidant activity of Mangifera indica L. extract (Vimang)," *Phytotherapy Research*, vol. 14, no. 6, pp. 424–427, 2000.

[96] S. Siswanto, W. Aroabal, V. Juniantiito, A. Grace, and F. D. Agustini, "The effect of mangiferin against brain damage caused by oxidative stress and inflammation induced by doxorubicin," *HAYATI Journal of Biosciences*, vol. 23, no. 2, pp. 51–55, 2016.

[97] J. Wattanathorn, S. Muchimapura, W. Thukham-Mee, K. Ingkanin, and S. Wittaya-Areekul, "Mangifera indica fruit extract improves memory impairment, cholinergic dysfunction, and oxidative stress damage in animal model of mild cognitive impairment," *Oxidative Medicine and Cellular Longevity*, vol. 2014, Article ID 132097, 7 pages, 2014.

[98] K. Kawpoomhae, M. Sukma, T. Ngwahirunpat, P. Opanasopit, and A. Sriprathanaporn, "Antioxidant and neuroprotective effects of standardized extracts of Mangifera indica leaf," *Thai Journal of Pharmaceutical Sciences*, vol. 34, no. 1, pp. 32–43, 2010.

[99] S. Ahmad, M. A. Sukari, N. Ismail et al., "Phytochemicals from Mangifera pajarost Kosterm and their biological activities," *BMC Complementary and Alternative Medicine*, vol. 15, no. 1, article no. 83, 2015.

[100] Y. Semamng, P. Pannengpetch, S. C. Chattipakorn, and N. Chattipakorn, "Pharmacological properties of pomegranate (Punica Granatum L.) in a preclinical model of inflammatory mechanism of mango (Mangifera Indica L.) and A. Sripattanaporn, "Antioxidant and neuroprotective effects of standardized extracts of Mangifera indica leaf," *Annals of the New York Academy of Sciences*, vol. 854, pp. 435–442, 1998.

[101] I. Naasani, H. Seimiya, and T. Tsuruo, "Telomerase inhibition, telomere shortening, and senescence of cancer cells by tea catechins," *Biochemical and Biophysical Research Communications*, vol. 249, no. 2, pp. 391–396, 1998.

[102] Y. Zhu, J. Hu, F. Shen, H. Shen, W. Liu, and J. Zhang, "The cytotoxic effect of 5-epigallocatechin against malignant glioma is enhanced by base-excision repair inhibitor methoxyamine," *Journal of Neuro-Oncology*, vol. 113, no. 3, pp. 375–384, 2013.

[103] S. Yoshizawa, T. Horiuichi, H. Fujiuki, T. Yoshida, T. Okuda, and T. Sugimura, "Antitumor promoting activity of (-)-epigallocatechin gallate, the main constituent of "Tannin" in green tea," *Phytotherapy Research*, vol. 1, no. 1, pp. 44–47, 1987.

[104] T. Kalaivani, C. Rajasekaran, and L. Mathew, "Free radical scavenging, cytotoxic, and hemolytic activities of an active antioxidant compound ethyl gallate from leaves of Acacia Nilotica(L.) wild. ex. delile subsp. Indica (Benth.) Brenan," *Journal of Food Science*, vol. 76, no. 6, pp. T144–T149, 2011.

[105] A. Prabhu, M. K. M. Krishnamoorthy, D. J. Prasad, and P. Naik, "Anticancer activity of friedelin isolated from ethanolic leaf extract of Cassia tora on Hela and HSC-1 cell lines," *Indian Journal of Applied Research*, vol. 3, no. 10, pp. 1–4, 2011.

[106] B. Badhani, N. Sharma, and R. Kakkar, "Gallic acid: a versatile antioxidant with promising therapeutic and industrial applications," *RSC Advances*, vol. 5, no. 35, pp. 27540–27557, 2015.

[107] J. Legault and A. Pichette, "Potentiating effect of β-caryophyllene on anticancer activity of α-humulene, isocaryophyllene and pacthaxel," *Journal of Pharmacy and Pharmacology*, vol. 59, no. 12, pp. 1643–1647, 2007.

[108] M.-Y. Chang and Y.-L. Shen, "Linaloolexhibitscytotoxiceffects by activatingantitumor immunity," *Molecules*, vol. 19, no. 5, pp. 6694–6706, 2014.

[109] D. Chauhduri, N. B. Ghate, S. S. Singh, and N. Mandal, "Methyl gallate isolated from Spondias pinnata exhibits anticancer activity against human glioblastoma by induction of apoptosis and sustained extracellular signal-regulated kinase 1/2 activation," *Pharmacognosy Magazine*, vol. 11, no. 42, pp. 269–276, 2015.

[110] K. Krishnan, A. Mani, and S. Jasmine, "Cytotoxic activity of bioactive compound 2, benzene Dichroxylic acid, mono 2-Ethylhexyl Ester extracted from a marine derived Streptomyces sp. VITSJK8," *International Journal of Molecular and Cellular Medicine*, vol. 3, pp. 246–254, 2014.

[111] C. Locatelli, R. Rosso, M. C. Santos-Silva et al., "Ester derivatives of gallic acid with potential toxicity toward L1210 leukemia cells," *Bioorganic & Medicinal Chemistry*, vol. 16, pp. 3791–3799, 2008.

[112] Y. Nakagawa and S. Tayama, "Cytotoxicity of propyl gallate and related compounds in rat hepatocytes," *Archives of Toxicology*, vol. 69, no. 3, pp. 204–208, 1995.

[113] J. V. Formica and W. Regelson, "Review of the biology of quercetin and related bioflavonoids," *Food and Chemical Toxicology*, vol. 33, no. 12, pp. 1061–1080, 1995.

[114] K. D. Croft, "The chemistry and biological effects of flavonoids and phenolic acids," *Annals of the New York Academy of Sciences*, vol. 854, pp. 435–442, 1998.
Evidence-Based Complementary and Alternative Medicine

[115] J. Ó. Moskaug, H. Carlsten, M. Myhrstad, and R. Blomhoff, "Molecular control of the biological effects of quercetin and quercitin-rich foods," *Mechanisms of Ageing and Development*, vol. 125, no. 4, pp. 315–324, 2004.

[116] A. V. Rao and L. G. Rao, "Carotenoids and human health," *Pharmacological Research*, vol. 55, no. 3, pp. 207–216, 2007.

[117] V. Anjaneyulu, J. S. Babu, and J. D. Connolly, "29-Hydroxy-mangiferonic acid from Mangifera indica," *Phytochemistry*, vol. 35, no. 5, pp. 1301–1303, 1994.

[118] A. J. Núñez Sellés, H. T. Véliz Castro, J. Agüero-Agüero et al., "Isolation and quantitative analysis of phenolic antioxidants, free sugars, and polyols from mango (Mangifera indica L.) stem bark aqueous decoction used in Cuba as a nutritional supplement," *Journal of Agricultural and Food Chemistry*, vol. 50, no. 4, pp. 762–766, 2002.

[119] K. Tawahra, R. Sadi, F. Qadan, K. Z. Matalka, and A. Nahrstedt, "A bioactive prodelphinidin from Mangifera indica leaf extract," *Zeitschrift fur Naturforschung*, vol. 65, no. 5–6, pp. 322–326, 2010.

[120] A. J. Núñez Sellés, M. D. Durruthy Rodríguez, E. R. Balseiro, L. N. González, V. Nicolais, and L. Rastrelli, "Comparison of major and trace element concentrations in 16 varieties of cuban mango stem bark (Mangifera indica L.)," *Journal of Agricultural and Food Chemistry*, vol. 55, no. 6, pp. 2176–2181, 2007.

[121] J. Rodríguez, D. Di Pierro, M. Gioia et al., "Effects of a natural extract from Mangifera indica L. and its active compound, mangiferin, on energy state and lipid peroxidation of red blood cells," *Biochimica et Biophysica Acta (BBA) - General Subjects*, vol. 1760, no. 9, pp. 1333–1342, 2006.

[122] Y. Y. Soong and P. J. Barlow, "Quantification of gallic acid and ellagic acid from longan (Dimocarpus longan Lour.) seed and mango (Mangifera indica L.) kernel and their effects on antioxidant activity," *Food Chemistry*, vol. 97, no. 3, pp. 524–530, 2006.

[123] J. P. Munafó, J. Didzbalis, R. J. Schnell, P. Schieberle, and M. Steinhaus, "Characterization of the major aroma-active compounds in mango (Mangifera indica L.) cultivars haden, white alfonso, praya sowy, royal special, and malindi by application of a comparative aroma extract dilution analysis," *Journal of Agricultural and Food Chemistry*, vol. 62, no. 20, pp. 4544–4551, 2014.

[124] M. Knödler, J. Conrad, E. M. Wenzig et al., "Anti-inflammatory 5-((1[Z]-heptadecenyl)- and 5-((8[Z],12[Z]-heptadecadienyl)-resorcinol from mango (Mangifera indica L.) peels," *Phytochemistry*, vol. 69, no. 4, pp. 988–993, 2008.

[125] Y. Zhong, Y.-S. Chiu, M.-H. Pan, and F. Shahidi, "Anti-inflammatory activity of lipophilic epigallocatechin gallate (EGCG) derivatives in LPS-stimulated murine macrophages," *Food Chemistry*, vol. 134, no. 2, pp. 742–748, 2012.

[126] P. Antonisamy, V. Duraipandian, and S. Ignacimuthu, "Anti-inflammatory, analgesic and antipyretic effects of friedelin isolated from Azima tetrandra Lam. in mouse and rat models," *Journal of Pharmacy and Pharmacology*, vol. 65, no. 8, pp. 1070–1077, 2011.

[127] E. S. Fernandes, G. F. Passos, R. Medeiros et al., "Anti-inflammatory effects of compounds alpha-humulene and (−)-(−)-trans-caryophyllene isolated from the essential oil of Cordia verbenacea," *European Journal of Pharmacology*, vol. 569, no. 3, pp. 228–236, 2007.

[128] J. Xing, J. Sun, H. You, J. Lv, J. Sun, and Y. Dong, "Anti-inflammatory effect of 3,4-oxo-isopropylidene-shikimic acid on acetic acid-induced colitis in rats," *Inflammation*, vol. 35, no. 6, pp. 1872–1879, 2012.

[129] G. A. González-Aguilar, C. Y. Wang, J. G. Buta, and D. T. Krizek, "Use of UV-C irradiation to prevent decay and maintain post-harvest quality of ripe 'Tommy Atkins' mangos," *International Journal of Food Science & Technology*, vol. 36, no. 7, pp. 767–773, 2001.

[130] D. Milenković, J. Dorović, S. Jeremić, J. M. Dimitrić Marković, E. H. Avdović, and Z. Marković, "Free Radical Scavenging Potency of Dihydroxybenzoic Acids," *Journal of Chemistry*, vol. 2017, Article ID 5936239, 9 pages, 2017.

[131] C. A. Rice-Evans, N. J. Miller, and G. Paganga, "Structure-antioxidant activity relationships of flavonoids and phenolic acids," *Free Radical Biology & Medicine*, vol. 20, no. 7, pp. 933–956, 1996.

[132] G.-H. Seol, P. Kang, H. S. Lee, and G. H. Seol, "Antioxidant activity of linalool in patients with carpal tunnel syndrome," *BMC Neurology*, vol. 16, no. 1, article no. 17, 2016.

[133] K. B. Pandey and S. I. Rizvi, "Plant polyphenols as dietary antioxidants in human health and disease," *Oxidative Medicine and Cellular Longevity*, vol. 2, no. 5, pp. 270–278, 2009.

[134] J. Terao, "Antioxidant activity of β-carotene-related carotenoids in solution," *Lipids*, vol. 24, no. 7, pp. 659–661, 1989.

[135] H. Palafoux-Carlos, E. M. Yahia, and G. A. González-Aguilar, "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*, vol. 135, no. 1, pp. 105–111, 2012.

[136] S. George, P. J. Benny, S. Kuriakose, and C. George, "Antibiotic activity of 2, 3-dihydroxybenzoic acid isolated from Flacourtia inermis fruit against multidrug resistant bacteria," *Asian Journal of Pharmaceutical and Clinical Research*, vol. 4, no. 1, pp. 126–130, 2011.

[137] M. Friedman, P. R. Henika, and R. E. Mandrell, "Antibacterial Activities of Phenolic Benzaldehydes and Benzoic Acids against Campylobacter jejuni, Escherichia coli, Listeria monocytogenes, and Salmonella enterica," *Journal of Food Protection*, vol. 66, no. 10, pp. 1811–1821, 2003.

[138] H. Pal Bais, T. S. Walker, F. R. Stermitz, R. A. Hufbauer, and J. M. Vivanco, "Enantiomeric-dependent phytotoxic and antimicrobial activity of (−)-catechin. A rhizosecreted racemic mixture from spotted knapweed," *Plant Physiology*, vol. 128, no. 4, pp. 1173–1179, 2002.

[139] S.-N. Park, Y. K. Lim, M. O. Freire, E. Cho, D. Jin, and J.-K. Kook, "Antimicrobial effect of linalool and α-terpineol against periodontopathic and cariogenic bacteria," *Anaerobe*, vol. 18, no. 3, pp. 369–372, 2012.

[140] J.-G. Choi, O.-H. Kang, Y.-S. Lee et al., "In vitro activity of methyl gallate isolated from Galla Rhois alone and in combination with ciprofloxacin against clinical isolates of Salmonella," *Journal of Microbiology and Biotechnology*, vol. 18, no. 1, pp. 29–32, 1993.
M. Hirasawa and K. Takada, "Multiple effects of green tea catechin on the antifungal activity of antimycotics against Candida albicans," *Journal of Antimicrobial Chemotherapy*, vol. 53, no. 2, pp. 225–229, 2004.

J. Tian, X. Zeng, H. Zeng, Z. Feng, X. Miao, and X. Peng, "Investigations on the antifungal effect of nero1 against aspergillus flavus causing food spoilage," *The Scientific World Journal*, vol. 2013, Article ID 230795, 2013.

S. Ito, Y. Nakagawa, S. Yazawa, Y. Sasaki, and S. Yajima, "Antiviral effect of catechins in green tea on influenza virus," *Antiviral Research*, vol. 68, no. 2, pp. 66–74, 2005.

M. Heng and Z. Lu, "Antiviral effect of mangiferin and isomangiferin on herpes simplex virus," *Chinese Medical Journal*, vol. 103, no. 2, pp. 160–165, 1990.

C. J. M. Kane, J. H. Menna, C.-C. Sung, and Y.-C. Yeh, "Methyl gallate, methyl-3,4,5-trihydroxybenzoate, is a potent and highly specific inhibitor of herpes simplex virus in vitro. II. Antiviral activity of methyl gallate and its derivatives," *Bioscience Reports*, vol. 8, no. 1, pp. 95–102, 1988.

J. M. Kratz, C. R. Andrigatti-Fröhner, P. C. Leal et al., "Evaluation of anti-HSV-2 activity of gallic acid and pentyl gallate," *Biological & Pharmaceutical Bulletin*, vol. 31, no. 5, pp. 903–907, 2008.

T. Prommajak, S. M. Kim, C.-H. Pan, S. M. Kim, S. Surawang, and N. Rattanapanone, "Identification of antioxidants in young mango leaves by LC-ABTS and LC-MS," *Chiang Mai University Journal of Natural Sciences*, vol. 13, no. 3, pp. 317–330, 2014.

B. Scanzocchio, R. Vari, C. Filesi et al., "Cyainidin-3-O-β-glucoside and protocatechuic acid exert insulin-like effects by upregulating PPARγ activity in human omental adipocytes," *Diabetes*, vol. 60, no. 9, pp. 2234–2244, 2011.

G. Zheng, K. Sayama, T. Okubo, L. R. Junrea, and I. Oguni, "Anti-obesity effects of three major components of green tea, catechins, caffeine and theanine, in mice," *In Vivo*, vol. 18, no. 1, pp. 55–62, 2004.

V. Duraiapandiyan, N. A. Al-Dhabi, S. S. Irudayaraj, and C. Sunil, "Hypolipidemic activity of friedelin isolated from Azima tetrapantha in hyperlipidemic rats," *Revista Brasileira de Farmacognosia*, vol. 26, no. 1, pp. 89–93, 2016.

R. E. Chapin, T. J. B. Gray, J. L. Phelps, and S. L. Dutton, "The effects of mono-(2-ethylhexyl)-phthalate on rat Sertoli cell enriched primary cultures," *Toxicology and Applied Pharmacology*, vol. 92, no. 3, pp. 467–479, 1988.

A. Nakamura, S. Fujiwara, I. Matsumoto, and K. Abe, "Stress repression in restrained rats by (R)-(-)-Linalool inhalation and gene expression profiling of their whole blood cells," *Journal of Agricultural and Food Chemistry*, vol. 57, no. 12, pp. 5480–5485, 2009.

T. H. C. Marques, M. L. B. G. C. Branco, and D. D. S. L. Marques, "Evaluation of the neuropharmacological properties of nero1 in mice," *World Journal of Neuroscience*, vol. 3, no. 1, pp. 32–38, 2013.

S. Schulz, C. Estrada, S. Yildizhan, M. Bopp, and L. E. Gilbert, "An antiaphrodisiac in Heliconius melpomene butterflies," *Journal of Chemical Ecology*, vol. 34, no. 1, pp. 82–93, 2008.

A. Conte, S. Pellegrini, and D. Tagliazucchi, "Effect of resveratrol and catechin on PCl2 tyrosine kinase activities and their synergistic protective effects on β-amyloid toxicity," *Drugs under Experimental and Clinical Research*, vol. 29, no. 5-6, pp. 243–255, 2003.

R. Zhu, L. Yang, L. Shen, J. Ye, J. Liu, and S. Hu, "ANG II-AT1 receptor pathway is involved in the anti-fibrotic effect of β-elemene," *Journal of Huazhong University of Science and Technology (Medical Sciences)*, vol. 29, no. 2, pp. 177–181, 2009.

A. Dalman, H. Eimani, H. Sepehri et al., "Effect of mono-(2-ethylhexyl) phthalate (MEHP) on resumption of meiosis, in vitro maturation and embryo development of immature mouse oocytes," *BioFactors*, vol. 33, no. 2, pp. 149–155, 2008.

F. Barla, H. Higashijima, S. Funai et al., "Inhibitive effects of alkyl gallates on Hyaluronidase and collagenase," *Bioscience, Biotechnology, and Biochemistry*, vol. 73, no. 10, pp. 2335–2337, 2009.

I. Park, J. Kim, S. Lee, and S. Shin, "Nematicidal activity of plant essential oils and components from Ajowan (Trachyspermum ammi), Allspice (Pimenta dioica) and Litsea (Litsea cubeba) essential oils against pine wood nematode (Bursaphelenchus Xylusilis)," *Journal of Nematology*, vol. 39, no. 3, pp. 275–279, 2007.

L. Tang, H. Xiang, Y. Sun et al., "Monopalmityloxy shikimic acid: Enzymatic synthesis and anticoagulation activity evaluation," *Applied Biochemistry and Biotechnology*, vol. 158, no. 2, pp. 408–415, 2009.

G. Marchesini, M. Brizi, G. Bianchi et al., "Nonalcoholic fatty liver disease: a feature of the metabolic syndrome," *Diabetes*, vol. 50, no. 8, pp. 1844–1850, 2001.

J. C. Fernández-Checa, N. Kaplowitz, A. Colell, and C. García-Ruiz, "Oxidative stress and alcoholic liver disease," *Alcohol Research and Health*, vol. 21, no. 4, pp. 321 pages, 1997.

L. P. James, P. R. Mayeux, and J. A. Hinson, "Acutaminophen-induced hepatotoxicity," *Drug Metabolism and Disposition*, vol. 31, no. 12, pp. 1499–1506, 2003.

Z. Yan and G. W. Caldwell, "Metabolism profiling, and cytochrome P450 inhibition & induction in drug discovery," *Current Topics in Medicinal Chemistry*, vol. 1, no. 5, pp. 403–425, 2001.

H. M. Ebeid, A. A. Y. Gibriel, H. M. A. -A. Al-Sayed, S. A. Elbehairy, and E. H. Motawe, "Hepatoprotective and Antioxidant Effects of Wheat, Carrot, and Mango as Nutraceutical Agents against CCl4–Induced Hepatocellular Toxicity," *Journal of the American College of Nutrition*, vol. 34, no. 3, pp. 228–231, 2015.

B. D. Hiraganahalli, V. C. Chinampudur, S. Deth et al., "Hepatoprotective and antioxidant activity of standardized herbal extracts," *Pharmacognosy Magazine*, vol. 8, no. 30, pp. 116–123, 2012.

S. Prasad, N. Kalra, and Y. Shukla, "Hepatoprotective effects of lupeol and mango pulp extract of carcinogen induced alteration in Swiss albino mice," *Molecular Nutrition & Food Research*, vol. 51, no. 3, pp. 352–359, 2007.

J. Pourahmad, M. R. Eskandari, R. Shakibaei, and M. Kamlinejad, "A search for hepatoprotective activity of fruit extract of mangifera indica L. against oxidative stress cytotoxicity," *Plant Foods for Human Nutrition*, vol. 65, no. 1, pp. 83–89, 2010.

S. Nithitanakool, P. Pithayanukul, and R. Bavovada, "Antioxidant and hepatoprotective activities of Thai mango seed kernel extract," *Planta Medica*, vol. 75, no. 10, pp. 1118–1123, 2009.
[175] J. Ojewole, “Antinflammatory, analgesic and hypoglycemic effects of Mangifera indica Linn. (Anacardiaceae) stem-bark aqueous extract,” Methods and Findings in Experimental and Clinical Pharmacology, vol. 27, no. 8, pp. 547–554, 2005.

[176] M. R. Islam, M. A. Mannan, M. H. B. Kabir, A. Islam, and K. J. Olival, “Analgesic, anti-inflammatory and antimicrobial effects of ethanolic extracts of mango leaves,” Journal of the Bangladesh Agricultural University, vol. 8, no. 2, pp. 239–244, 2010.

[177] M. D. Kazatchkine and S. V. Kaveri, “Immunomodulation of autoimmune and inflammatory diseases with intravenous immune globulin,” The New England Journal of Medicine, vol. 345, no. 10, pp. 747–755, 2001.

[178] T. Wegmann, “Foetal protection against abortion: Is it immunosuppression or immunostimulation?” Annales de l’Institut Pasteur/Immunologie, vol. 135, pp. 177–180, 1984.

[179] M. A. Dimopoulos and V. Eleutherakis-Papaiakovou, “Adverse effects of thalidomide administration in patients with neoplastic diseases,” American Journal of Medicine, vol. 117, no. 7, pp. 508–515, 2004.

[180] G. Garrido, M. Blanco-Molina, R. Sancho, A. Macho, R. Delgado, and E. Muñoz, “An aqueous stem bark extract of Mangifera indica (Vimang*) inhibits T cell proliferation and TNF-induced activation of nuclear transcription factor NF-kB,” Phytotherapy Research, vol. 19, no. 3, pp. 211–215, 2005.

[181] J. Leiro, D. García, J. A. Arranz, R. Delgado, M. L. Sanmartín, and J. Leiro, “An Anacardiaceae preparation reduces the expression of inflammation-related genes in murine macrophages,” International Immunopharmacology, vol. 4, no. 8, pp. 991–1003, 2004.

[182] N. Makare, S. Bodhankar, and V. Rangari, “Immunomodulatory activity of alcoholic extract of Mangifera indica L. in mice,” Journal of Ethnopharmacology, vol. 78, no. 2–3, pp. 133–137, 2001.

[183] S. Sahu, B. K. Das, J. Pradhan, B. C. Mohapatra, B. K. Mishra, and J. Leiro, “An Anacardiaceae preparation reduces the expression of inflammation-related genes in murine macrophages,” International Immunopharmacology, vol. 4, no. 8, pp. 991–1003, 2004.

[184] S. Shailajan, S. Menon, S. Kulkarni, and B. Tiwari, “Standardized extract of Mangifera indica L. leaves as an anticytocobacterial and immunomodulatory agent,” Pharmacognosy Communications, vol. 6, no. 3, pp. 137–147, 2016.

[185] R. L. Siegel, K. D. Miller, S. A. Fedewa et al., “Colorectal cancer statistics, 2017,” CA: A Cancer Journal for Clinicians, vol. 67, no. 3, pp. 177–193, 2017.

[186] C. J. L. Murray and A. D. Lopez, “Mortality by cause for eight regions of the world: global burden of disease study,” The Lancet, vol. 349, no. 9061, pp. 1269–1276, 1997.

[187] M. C. Archer, “Cancer-Causing Agents,” Canadian Medical Association Journal, vol. 122, no. 12, p. 1403, 1980.

[188] World Health, WHO handbook for reporting results of cancer treatment, Geneva: World Health Organization, 1979.

[189] C. J. Dillard and J. Bruce German, “Phytochemicals: nutraceuticals and human health,” Journal of the Science of Food and Agriculture, vol. 80, no. 12, pp. 1744–1756, 2000.

[190] H. Kim, H. Kim, A. Mosaddik, R. Gyawali, K. S. Ahn, and S. K. Cho, “Induction of apoptosis by ethanolic extract of mango pulp and comparative analysis of the chemical constituents of mango pulp and flesh,” Food Chemistry, vol. 133, no. 2, pp. 416–422, 2012.

[191] A. Corrales-Bernal, L. A. Urango, B. Rojano, and M. E. Maldonado, “In vitro and in vivo effects of mango pulp (Mangifera indica cv. Azucar) in colon carcinogenesis,” Archives Latinoamericanos de Nutrición, vol. 64, no. 1, pp. 16–23, 2014.
[266] B. Dineshkumar, A. Mitra, and M. Manjunatha, “A comparative study of alpha amylase inhibitory activities of common anti-diabetic plants at Kharagpur 1 block,” *Journal of Advanced Pharmaceutical Technology & Research*, vol. 4, no. 2, pp. 115–121, 2010.

[267] A. O. Aderibigbe, T. S. Emudianughe, and B. A. S. Lawal, “Antihyperglycaemic effect of *Mangifera indica* in rat,” *Phytotherapy Research*, vol. 13, no. 6, pp. 504–507, 1999.

[268] Y. Tanko, O. Alladey, M. K. Ahmed, A. Mohammed, and K. Y. Musa, “The effect of methanol leaves extract of Ficus Glumosa on gastrointestinal motility and on castor oil induced diarrhea in laboratory animals,” *Journal of Natural Product and Plant Resources*, vol. 2, no. 2, pp. 239–243, 2012.

[269] E. N. Mangola, “Use of traditional medicines in diabetics mellitus,” *Diabetics Care*, vol. 13, no. 8, 1990.

[270] T. Miura, H. Ichiki, I. Hashimoto et al., “Antidiabetic activity of a xanthone compound, mangiferin,” *Phytotherapy Research*, vol. 8, no. 2, pp. 85–87, 2001.

[271] A. Waheed, G. A. Miana, and S. I. Ahmad, “Clinical investigation of hypoglycemic effect of leaves of *Mangifera indica* in type-2 (NIDDM) diabetes mellitus,” *Pakistan Journal of Pharmacology*, vol. 23, no. 2, pp. 13–18, 2006.

[272] S. R. Sharma, S. K. Dwivedi, and D. Swarup, “Hypoglycaemic potential of *Mangifera indica* leaves in rats,” *International Journal of Pharmacognosy*, vol. 35, no. 2, pp. 130–133, 1997.

[273] N. Wadood, N. Ahmad, and A. Wadood, “Effect of *Mangifera indica* on blood glucose and total lipid levels of normal and alloxan diabetic rabbits,” *Pakistan Journal of Medical Research*, vol. 39, no. 4, pp. 142–145, 2000.

[274] A. Bhowmik, L. A. Khan, M. Akhter, and B. Rokeya, “Studies on the antidiabetic effects of *Mangifera indica* stem-barks and leaves on non-diabetic, type 1 and type 2 diabetic model rats,” *Bangladesh Journal of Pharmacology*, vol. 4, no. 2, pp. 110–114, 2009.

[275] B. J. Marshall and J. R. Warren, “Unidentified curved bacilli in the stomach of patients with gastritis and peptic ulceration,” *The Lancet*, vol. 1, no. 8390, pp. 1311–1314, 1984.

[276] D. I. Stewart and R. Ackroyd, “Peptic ulcers and their complications,” *Surgery*, vol. 29, no. 11, pp. 568–574, 2011.

[277] Z. P. Lima, J. A. Severi, C. H. Pellizzon et al., “Can the aqueous decoction of mango flowers be used as an antiulcer agent?” *Journal of Ethnopharmacology*, vol. 106, no. 1, pp. 29–37, 2006.

[278] J. A. Severi, Z. P. Lima, H. Kushima et al., “Polyphenols with antiulcerogenic action from aqueous decoction of mango leaves (*Mangifera indica L.*),” *Molecules*, vol. 14, no. 3, pp. 1098–1110, 2009.

[279] N. Neelimma, M. Sudhakar, M. B. Patil, and B. V. S. Lakshmi, “Anti-ulcer activity and HPTLC analysis of *Mangifera indica* L. leaves,” *International Journal of Pharmaceutical and Phytopharmacological Research*, vol. 1, no. 4, pp. 146–155, 2017.

[280] A. J. Akindele, F. R. Aigbe, J. A. Olowe, B. O. Oduntan, and O. O. Adeyemi, “Gastroprotective effects of DAS-77 (a Phyto-medicine) in ulcer models in rats,” *Tropical Journal of Pharmaceutical Research*, vol. 11, no. 5, pp. 783–791, 2012.

[281] K. Nethravathi, M. S. Chandrashekar, T. A. Siddique, and G. Lakshminarayana, “Evaluation of antiulcer activity of *Mangifera indica* kernel, vitamins and zinc sulphate on pylorus ligation and ethanol induced ulcer models in rats,” *International Journal of Phytopharmacology*, vol. 6, pp. 86–97, 2015.