A mini-review on the Phytochemistry and Pharmacology of the medicinal plant species *Persea americana* Mill. (Lauraceae)

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**ABSTRACT**

**Aim:** To provide update knowledge on phytochemistry and pharmacology of *Persea americana*.

**Study Design:** Multidisciplinary advanced bibliographic surveys, utilization of ChemBioDraw software package and dissemination of the resulted knowledge.

**Methodology:** A literature search was conducted to get information about the phytochemistry and pharmacognosy of *P. americana* from various electronic databases (PubMed, PubMed Central, Science Direct, Scielo, DOAJ and Google scholar). The scientific name of this plant species was used as a keyword for the search, along with the terms phytochemistry and pharmacognosy. The chemical structures of *P. americana* naturally occurring compounds were drawn using ChemBioDraw Ultra 12.0 software package.

**Results:** Findings from different studies revealed that this plant is commonly and traditionally used as an edible fruit. *P. americana* is reported to possess various biological virtues like antiviral, antioxidant, antimicrobial, anti-inflammatory, antihyperglycemic, analgesic, antiluetic, hypertensive, antihypertensive, anticonvulsant, vasorelaxant and have an effect on body weight and different toxicological studies carried out demonstrated satisfactory results. These properties are due to the presence of numerous naturally occurring phytochemicals like tannins, alkaloids, phenols, saponins and flavonoids. *P. americana* is also rich in biologically important fatty acids like oleic acid and palmitic acid, minerals and vitamins, which makes it a healthful food. While Lutein is the most predominant carotenoid found in his fruit.

**Conclusion:** The present review can therefore help inform future scientific research towards the development of novel drugs of relevance from *P. americana* for the improvement of human health and wellbeing.

**Keywords:** Traditional Medicine, *Persea americana*, Phytochemicals, Scientific validation, Biodiversity valorization.

**INTRODUCTION**

**Background**

As per the records of World Health Organization (WHO), it is assumed that more than 60% of the global population is using the traditional medicine system in order to overcome several health related issues.1-2 The use of this medicine is rising in developing countries due to its low cost precisely where rural and tribal population is higher.3,4 Recent findings revealed that over 80% of the African population relies on medicinal plant species for their primary healthcare.5-11 Due to the unaffordability of conventional drugs, in the Democratic Republic of the Congo (DRC) medicinal plants represent the key product for both urban and rural populations for their healthcare needs. These plants have found to have great therapeutic relevance for fighting major health problems.5-11

*Persea americana* Mill. (Lauraceae) has been greatly appreciated in recent times and researchers have found scientific support for its use in folk medicine.12 The parts of this plant have various applications in ethnomedicine, ranging from treatment of hypertension, diarrhea, dysentery, toothache, anemia, intestinal parasites to the area of skin treatment and beautification.13 The leaves, seeds and fruits of *P. americana* are reported to possess anti-inflammatory, analgesic, antimicrobial, antiviral, antihypertensive, antihypoglycemic, antiluetic, anticonvulsant, larvicidal Antihepatotoxic, vasorelaxant, toxicological activities.12,14-21 The analysis of part extracts of *P. americana* revealed the presence
of vitamins A, B2, C, K, folic acid, lutein, zeaxanthin, coenzyme Q10 and beta-carotene, isorhamnetin, luteolin, rutin, quercetin and apigenin, olefinic acid, acetylenic bonds, furanoic acid, dimmers of flavonols and oligomeric proanthocyanidins, β-D-glucoside of 8-hydroxyabscisic acid and epi-dihydrophaseic acid β-d-glucoside.14,22-24

The present review aims to give updated information on the phytochemistry and pharmacognosy of this useful medicinal plant species.

Botanical description and geographic distribution
P. americana Mill. from the Lauraceae family is commonly known as avocado and alligator pear. It is a medium to large tree, 9-20m in height. The avocado is classified as an evergreen, although some varieties lose their leaves for a short time before flowering. The tree canopy ranges from low, dense, and symmetrical to upright and asymmetrical. Leaves are 7-41cm in length and variable in shape (elliptic, oval, and lanceolate). They are often pubescent and reddish when young, becoming smooth, leathery, and dark green when mature while. Flowers are yellowish green and 1-1.3 cm in diameter. The many-flowered inflorescences are borne in a pseudoterminal position knowing that the central axis of the inflorescence terminates in a shoot. The fruit is a berry, consisting of a single large seed, surrounded by a buttery pulp. It contains 3-30% oil (Florida varieties range from 3% to 15%). The skin is variable in thickness and texture while the fruit colors once ripen is green, black, purple, or reddish, depending on the variety. The fruit shape ranges between spherical and pyriform, and weighs up to 2.3 kg.25 Originally, it was only native to humid tropical areas of Mexico until it was later cultivated to other regions of Latin America as well as to USA and Europe.26

Ethno-botanical uses
P. americana has been traditionally cultivated for food and medicinal purposes due to its high nutrition content as well as for its therapeutic virtues.27 This plant has a diverse application in ethnomedicine, ranging from treatment of hypertension, diarrhoea, dysentery, toothache, intestinal parasites to the area of skin treatment and beautification.13 It was also used by women in the form of an ointment and also for treating skin eruptions.27 Leaf and seed extracts have been shown a variety of medicinal applications and are particularly used as antibiotic.28

PHYTOCHEMISTRY OF P. AMERICANA
Rosalinda et al.29 reported the presence of alkaloids, saponins, unsaturated steroids and triterpenoids (Leucoanthocyanins), fats and oils in the ethanol extract of P. americana . Meanwhile, Uzor et al.15 reported the presence of flavonoids, steroids, saponins, tanins, alkaloids, cyanogenic glycoside and

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Table 1  Nutrients of Hass Avocado [27, 36, 37]

<table>
<thead>
<tr>
<th>N°</th>
<th>Analyte</th>
<th>Quantity (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Total sugar</td>
<td>0.2</td>
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<tr>
<td>2</td>
<td>High-monounsaturated fatty acids</td>
<td>6.7 g or 114 kcal</td>
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<tr>
<td>3</td>
<td>Sodium</td>
<td>5.5 mg</td>
</tr>
<tr>
<td>4</td>
<td>Potassium</td>
<td>345 mg</td>
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<tr>
<td>5</td>
<td>Magnesium</td>
<td>19.5 mg</td>
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<tr>
<td>6</td>
<td>Vitamin A</td>
<td>43 µg</td>
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<tr>
<td>7</td>
<td>Vitamin C</td>
<td>6.0 mg</td>
</tr>
<tr>
<td>8</td>
<td>Vitamin E</td>
<td>1.3 mg</td>
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<tr>
<td>9</td>
<td>Vitamin K_i</td>
<td>14 µg</td>
</tr>
<tr>
<td>10</td>
<td>Folate</td>
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<table>
<thead>
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<th>N°</th>
<th>Analyte</th>
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<tr>
<td>11</td>
<td>Vitamin B-6</td>
<td>0.2 mg</td>
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<tr>
<td>12</td>
<td>Niacin</td>
<td>1.3 mg</td>
</tr>
<tr>
<td>13</td>
<td>Pantothenic acid</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>14</td>
<td>Riboflavin</td>
<td>0.1 mg</td>
</tr>
<tr>
<td>15</td>
<td>Choline</td>
<td>10 mg</td>
</tr>
<tr>
<td>16</td>
<td>Lutein/ Zeaxanthin</td>
<td>85 mg</td>
</tr>
<tr>
<td>17</td>
<td>Phytosterols</td>
<td>57 mg</td>
</tr>
<tr>
<td>18</td>
<td>Dietary fiber</td>
<td>4.6 g</td>
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Table 2  Fatty acid composition of Avocado oil [27]

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<tr>
<td>Palmitoleic acid</td>
<td>5.69</td>
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<tr>
<td>Stearic acid</td>
<td>0.69</td>
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<tr>
<td>Oleic acid</td>
<td>50.95</td>
</tr>
<tr>
<td>Linoleic acid</td>
<td>13.87</td>
</tr>
<tr>
<td>Linolenic acid</td>
<td>0.58</td>
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</table>
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A mini-review on the ... phenol present in both extract with ethanol extract having more of flavonoids, saponins and tannins in the seed (kernel) extract. Tocopherols have been identified as well in the avocado acetone extract.

The isolation of the bioactive phytoconstituents of P. americana leaves (Lauraceae), yielded, isorhamnetin, luteolin, rutin, quercetin and apigenin. Isorhamnetin was fully characterized as reported by Owolabi et al.12

P. americana contains a significant amount of oil compared to other fruits.30 However, several secondary metabolites have been isolated from different parts of P. americana. The predominant carotenoid in Avocado is Lutein while other carotenoids such as present α-carotene, β-carotene, zeaxanthin, neoxanthin and violaxanthin are in small quantity. These lipophilic carotenoids may have potential anti-carcinogenic effects.12

The avocado seed also contains various classes of natural products such as phytosterols and triterpenes,33 fatty acids with olefinic, acetylenic bonds, furanoic acid, dimmers of flavonols and oligomeric proanthocyanidins, β-D-glucoside of 8-hydroxyabscisic acid and epi-dihydropha-seic acid β-d-glucoside.14 The findings of the phytochemical analysis of the ethanol seed extract indicated the presence of alkaloids, saponins, unsaturated steroids and triterpenoids (Leucoanthocyanins), fats and oils.29

The avocado fruit contains a lot of nutrients, and this includes its high content of essential minerals and vitamins. Several studies reported that P. americana is also a rich source of vitamins such as A, C, E, K, B1, B2, B6, B9 and minerals such as phosphorus, sodium, magnesium, potassium, iron and zinc, coenzyme Q10, beta-carotene, folic acid, lutein and zeaxanthin14,22-24 (tables 1 and 2).

The proximate analysis of this fruit based on the dry weight showed the presence of following nutrients namely ash (4.2%), proteins (8.1%), oil (70%), dietary fibers (7.2%) and carbohydrates (10.5%). It also contains tannins 2.45g/kg wt of the seed28 and after the harvest, the oil content was found to change in terms of maturity between 49.5% and 70% from the raw material.35

The presence of other fatty acids such as lignoceric acid, arachidic acid, margaric acid, behenic acid, gadolenic acid, docosadienoic, myristic and eicosanoic acids in small amounts has been found in analyses of the oil.19-21 The oil fortunately retains most of the phytochemicals and carotenoids present in the fruit.27

The figure 2 gives different chemical structures of compounds isolated from P. Americana.
A mini-review on the ...
A mini-review on the...

Koto-te-Nyiwa Ngbolua, et al.

- catechin
+ catechin
apigenin
astragalin
luteolin
luteolin-7-O-glc
quercetin
Quercetin-3-O-D-diglo
Afzelin
Figure 2  Different chemical structures of compounds isolated from *P. americana*
BIOLOGICAL ACTIVITIES AND PHARMACOGNOSY

Different bioactivities of *P. americana* are presented in the table 3.

**Antiviral activity**
De-Ameida et al reported the infusion and ethanol extract of dried leaves of *P. americana* were compared with respect to their inhibitory activities of viral replication in vitro. The chosen viruses for the initial screening were adenovirus type 3 (AD3), HSV-1, and ADV. The ethanol extract was only tested against HSV-1 and ADV. The infusion was active against the 3 viruses, whereas the ethanol extract did not show any activity under the experimental conditions employed.

**Antioxidant activity**
Banji et al. reported the antioxidant activities of the seed oil of which the flavonoid content (80.00±1.41 mgQE/g) was ~10 folds higher than the phenolic content (8.27±0.06 mgGAE/g). The DPPH radical scavenging value was found to be 51.54±0.25% with an IC50 value of 4.68±0.02 mg/mL and reducing power with an average absorbance of 0.85±0.01 and an IC50 value of 0.001±0.02 mg/mL. Gallic acid showed better antioxidant activities than the oil studied. Compounds were evaluated for their ability to scavenge free radical using DPPH and H2O2 systems. The IC50 (mg/mL) of quercetin was 4.82 x 10−5; rutin, 1.37 x 10−4; luteolin, 3.34 x 10−4 and isorhamnetin, 4.41 x 10−4. H2O2 scavenging activity of the compounds was quercetin > rutin > isorhamnetin > luteolin > apigenin > BHA (p > 0.05). The fruit is considered one of the most potent antioxidant fruit in the world because of its high content of mono unsaturated fats.

**Hypoglycemic activity**
Anita et al. reported the hypoglycemic effects of *P. americana* aqueous leaf extract in the normal rats. The maximum antidiabetic activity was reached at 6 h after a single dose of the extract was administered, producing 60.02 ± 6.83% reduction in the blood glucose level.

**Heptoprotective and dermatological activities**
The oil has also been used for the treatment of skin wounds, stretch marks and psoriasis. It also possesses hepatoprotective activity.

**Vasorelaxant activity**
It is reported that the aqueous leaves extract of the avocado has some vaso-relaxant effect on isolated rats and this effect is dependent on the synthesis or release of endothelium–derived relaxing factors as well as the release of the prostanoid, thus inhibiting Ca2+ influx through calcium channels.

The aqueous extract of *P. americana* (0.01-12.8 mg/mL) produced a concentration-related vasorelaxation response in the rings of rat aorta with intact endothelium pre-contracted with noradrenaline (1 x 10−7 M), with an EC50 of 0.88 ± 0.03 mg/mL. In the endothelium-denuded rings, the vasorelaxant action of the aqueous extract of *P. americana* was significantly attenuated (EC50 4.14F252.18 mg/mL). Cumulative addition of acetylcholine (1.1 x 10−4 to 1.4 x 10−5 M) produced relaxation of endothelium-intact rat aortic rings pre-contracted with noradrenaline (1 x 10−7 M). The vasorelaxant effect was significantly reduced by L-NAME (10−4 M) and methylene blue (10−6), but not affected by indomethacin (10−5M). The aqueous extract of *P. americana* (1 or 5 mg/mL) produced a rightward shift of the concentration- response curves to noradrenaline (1 x 10−9 to 1 x 10−9 M) and potassium chloride (10−4 mM). In fact, this activity was blocked by L-NAME or methylene blue, suggesting that the vasorelaxation is dependent on the synthesis and release of endothelium-derived relaxing factors (EDRFs). The blockade by indomethacin suggests that *P. americana* may also act by activating PGI2 and PGE2 receptors. The vasorelaxant effect may also be produced by the inhibition of Ca2+ mobilization through voltage-dependent channels and, to a lesser extent, through receptor-operated channels.

**Analgesic and Anti-inflammatory activities**
The aqueous extract of *P. americana* leaves caused a significant and dose-dependent inhibition of the control writhes. The inhibition by 1600 mg/kg extract was similar to that produced by 100 mg/kg of acetylsalicylic acid (57.2% and 58.0%, respectively). The inhibition (87.2%) shown by 800 mg/kg of the extract was same as morphine (2 mg/kg, 87.0%). There was a significant and dose- dependent inhibition of both phases, by the extract. A greater inhibition (77.1%) was produced by the extract (800 mg/kg) compared with acetylsalicylic acid (68%) in phase II of the test. The aqueous leaf extract of *P. americana* (800 mg/kg) produced a significant inhibition of the swelling caused by carrageenan at 3h. This effect was similar to that produced by indomethacin in the same duration.

**Antimicrobial activity**
The antimicrobial activity of seed extract of *P. americana* against *Escherichia coli*, *Staphylococcus aureus* and *Candida albicans* was determined using the agar well diffusion technique. The ethanol and petroleum ether solvents were used for the extraction and they demonstrated promising activity against...
the tested organisms. The potency of ethanolic extract was more pronounced than the petroleum ether against *E. coli* with a maximum zone of inhibition of 26.0mm at 25mg/ml, followed by *S. aureus* and *C. albicans* with a zone of inhibition of 21.0 mm and 17.0 mm at a concentration of 25mg/ml. The minimum inhibitory concentration (MIC) showed that ethanol extract had the lowest MIC value of 0.625 mg/ml against *E. coli*, while the minimum bactericidal concentration (MBC) showed that ethanol had the lowest value at 1.25 mg/ml against *S. aureus* which indicated higher potency.\(^\text{15}\)

**Antiulcer effect**

The study was carried out to investigate the antiulcer activity of aqueous leaf extract of *P. americana*. Groups of albino rats were pretreated orally with aqueous leaf extract of the plant before the administration of the ulcerogenic drugs-indomethacin and ethanol. The extract produced significant and dose-dependent antiulcer activity against indomethacin- and ethanol-induced ulcers in rat.\(^\text{19}\)

**Hypertensive activity**

The intravenous administration of doses of *P. americana* leaf aqueous and methanol extracts ranging from 6.25 to 50 mg/kg (pilot study indicated that doses above 50 mg/kg caused death of rats within 10 min of administration; therefore, the highest screening dose for i.p. injections was 50 mg/kg) to normotensive anesthetized rats produced dose-related hypotensive effects. The results revealed that dose above 12.5 mg/kg displayed hypotensive effects. Also, the duration of action appeared to be dose dependent. The aqueous extract of *P. americana* has been shown to produce vasorelaxation of the rat aortic ring and lower blood pressure. The seeds of *P. americana* has been reported to lower blood pressure in normotensive and hypertensive rat models; with reduction in the total cholesterol, LDL and triacylglycerol in the plasma, kidney, liver and heart of the hypertensive rat model at high dose of the seed extract.\(^\text{12,17}\)

**Antiepoxetoxic activity**

The methanolic extract of *P. americana* could be protective against liver toxicity and oxidative stress arising from acute paracetamol intoxication as reported in the literature.\(^\text{25}\) The mechanism of this protection is probably due to an antioxidant action of catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase, which are the primary intracellular defense mechanisms to cope with increased oxidant stress. The activities of the antioxidant enzymes measured (SOD and CAT) did not change significantly in normal rats treated compared to the methanolic leaf extract of *P. americana* However, the methanolic extract significantly induced the activity of these enzymes during hepatic damage produced by acute paracetamol toxicity. The methanolic leaf extract of *P. americana* and its hepatoprotective action against liver toxicity due to acute paracetamol toxicity make it a potential agent against liver diseases and other pathologies associated with oxidative stress.\(^\text{25}\)

**Larvicidal activity**

Rosalinda et al.\(^\text{29}\) reported the evidence of larvicidal toxicity (activity) of different parts of *P. americana* extracted with n-hexane and ethanol. The n-hexane extract from the seeds exhibited the highest toxicity with LC\(_{50}\) and LC\(_{90}\) values of 9.82 mg/L and 22.19 mg/L, respectively, while the ethanol seed extract exhibited LC\(_{50}\) of 16.48 mg/L and LC\(_{90}\) of 45.77 mg/L, respectively. This was closely followed by the ethanol extract of the peels with an LC\(_{50}\) of 10.35 mg/L and LC\(_{90}\) of 26.29 mg/L. The pulp extracted with ethanol also yielded a great larvicidal toxicity with LC\(_{50}\) of 21.32 mg/L and LC\(_{90}\) of 59.45 mg/L.

**Anticonvulsant effect**

Aqueous leaf extract of *P. americana* demonstrated an anticonvulsant activity in mice. The effectiveness of the plant extract in the experimental convulsion paradigm probably used suggests that the plant could be used in both petit and grand mal types of epilepsy. The plant’s leaf extract was relatively more effective in Pentylenetetrazole (PTZ)- and picrotoxin (PCT)-induced convulsions than in bicuculline (BCL)-induced seizures. In general, the average onset and duration of convulsion was markedly delayed and reduced, respectively. These findings tend to show that *P. americana* leaf aqueous extract might have inhibited and/or attenuated PTZ-, PCT- and BCL-induced seizures of the mice used by enhancing, or in some ways interfering with, GABAergic action and/or neurotransmission.\(^\text{21}\)

**Effect on body weight**

It is evident from Brail et al that the administration of aqueous and methanolic leaf extracts of *P. americana* caused a reduction in body weight compared with the hyperlipidemic controls. It could be that *P. americana* leaf extracts increase the catabolism of lipids accumulated in the adipose tissue, resulting in a decrease in the mean body weight.\(^\text{34,39}\)

**Reported Toxicological studies**

When the fruits extract of *Persea americana* administered to wistar rats for acute toxicity studies, the animals did not exhibit any sign of toxicity even when large doses were given. The maximum tolerable dose (MTD) was therefore determined to be ≥ 10g/kg of body weight. The extract was found to...
significantly decrease (p < 0.05) the activity of liver and heart enzymes in the treated animals when compared with the control. The extract decreased total cholesterol (TC) by 37.97%, triglycerides by 37.87%, very low density lipoproteins (VLDL) by 47.41%, low density lipoproteins (LDL) by 59.57%, and at the same time increased high density lipoprotein (HDL) by 3.64%. The extract also decreased the prothrombin time (PT) and the partial prothrombin plasmin time with kaolin (PPTK). These results are discussed with regard to the preventive and possible curative values of this extract as a potential inhibitor of cardiovascular diseases and in the regulation of blood clotting time due to its significant vitamin K content.14 Eduedo et al.16 demonstrated that the ethanolic extract of *P. americana* seed showed an acute toxic effect at concentration starting at 500 mg/kg. In vivo mutagenicity on peripheral blood cells of the seed extract was not observed.

**Anticancer effect**

A triterpenoid compound isolated from the seed of *Persea Americana* displayed cytotoxic effect against breast MCF-7 (IC50 62 µg/ml) and liver Hep G2 (IC50 12 µg/ml) cancer cell lines and was safe to normal cells.10 While, Abiodun et al.10 isolated from the root bark of *P. americana* an alkene lactone namely 4-hydroxy-5-methylene-3-unde-cyclenedihydrofurano-2(3H)–one which displayed a significant anticancer activity at the dose of 1 and 10 µg/mL. This class of compound caused a stimulatory effect on tumorigenic MCF-7 cells through a decrease of α4-, α6-, β1- and β3- integrin expression.

The work of D’Ambrosia at al.15 revealed that two aliphatic acetogenin constituents namely (2S,4S)-2,4-dihydroxyheptadec-16-enyl acetate and (2S,4S)-2,4 dihydroxyheptadec-16-ynyl acetate isolated from the fruit of *P. americana* exert their anticancer effect by blocking the signaling pathway of EGFR (Tyr 1173), C-RAF (Ser 338) and ERK ½ (Thr 202/Tyr 204) phosphorylation cascade.

**CONCLUSION**

Medicinal plant species are rich in secondary metabolites of pharmaceutical and medicinal relevance. The advantages of their therapeutic uses in various ailments are their safety besides being economical, effective and their availability. The current mini review was carried out with the aim of updating knowledge on the phytochemistry and various pharmacological properties of *P. americana* as common and traditionally edible fruit. The literature survey revealed that *P. americana* is a pharmacologically and chemically much studied plant species, although the diversity of secondary metabolites present in this plant species is enormously various.

**REFERENCES**


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