Eurasian J. Sci. Eng., 2024, 10(2), 46-71
https://doi.org/10.23918/eajse.v10i2p04

Published by Tishk International University
Available at: https://eajse.tiu.edu.iq/submit/

RESEARCH ARTICLE Open Access

Biological Activity and Taxonomy of *Persea americana* Mill: A Systematic Review

Abdulrahman Mahmoud Dogara [1] *

[1] Biology Education Department, Tishk International University, Erbil, Iraq

Article History
Received: 16.01.2024
Revised: 20.03.2024
Accepted: 07.04.2024
Published: 02.05.2024
Communicated by: Dr. Orhan Tug
**Email address:*
abdulrahman.mahmud@tiu.edu.iq
**Corresponding Author*

Abstract:
Medicinal plants are the main raw materials utilized in the manufacture of pharmaceutical products around the world. Avocado (*Persea americana* Mill.) is a high-nutrient tropical fruit of the Lauraceae family. The study provides a concise summary of the most important results from the many studies conducted on *P. americana* since 2010 that have sought to identify active principles found in the plant that can treat human ailments. To find published articles, searches were conducted through Google Scholar, PubMed, ScienceDirect, Web of Science, BioMed Central, Science, Scopus, and Springer. In the 113 articles published, it was discovered that the plant extract worked well against cancer, free radicals, bacteria, parasites, inflammation, and diabetes. The chemical compound that was mentioned the most frequently was polyphenol. Clinical studies involving humans are necessary to confirm and improve the effectiveness of avocado seed, peel, and leaf extracts in the treatment of diseases. Although the safety of avocado extract has been shown in animal models, it is imperative to evaluate the dosage and potential adverse effects in humans before deeming it an effective and safe treatment. The extract of *P. americana* may have a significant impact on the advancement of nutraceuticals.

Keywords: *Antioxidants; Anticancer; Avocado; Antimicrobial*

1. Introduction

The use of medicinal plants is becoming more and more recognized on a global scale. Finding phytochemicals that can replace synthetic molecules in food, pharmaceuticals, and cosmetics is becoming an increasingly popular goal in the modern day. The product was developed in line with customer concerns regarding the safety of synthetic chemical products since these compounds are believed to induce or exacerbate adverse health consequences. Products containing preservatives or synthetic additives are being replaced by those that are more natural and healthful [1]. Avocado (*Persea americana*) is a nutrient-dense tropical fruit in the Lauraceae family [2]. A fruit native to the tropics and subtropics. Over the past 10 years, avocado production has expanded due to its taste, texture, medicinal, and nutritional qualities, making it a staple on menus around the world. Avocado is a significant tropical crop that contains a high amount of unsaturated fatty acids, fiber, vitamins B and E, and various other nutrients [3]. The global demand for avocados has been steadily expanding in recent years, driven by their significant nutritional value and health benefits [4]. Avocados are an excellent source of healthy fat. Avocado is not only a staple crop in many countries around the world, but its medicinal qualities have also made it a popular ingredient in traditional medicine [5]. The current review of the literature did not yield comprehensive analyses of *Persea americana*. The plants have only been attempted to be reviewed by [6-8]. The purpose of this review was to provide an up-to-date and thorough assessment of *Persea americana's* biological potential. This study will examine existing research on the biological use of avocado and its by-products, including leaves, peel, and seeds.

2. Methodology

Inclusion criteria: Elsevier, Springer, Science Direct Elsevier, Google Scholar, Taylor & Francis, Pub med, and the Scopus database were searched using the terms chemical composition, *Persea americana*, antioxidant, antibacterial, anti-diabetic, anticancer, antiviral, traditional medicine, ethnopharmacology, toxicity, cytotoxic action, chemical composition, mineral elements, GCMS analysis, anti-inflammatory, antimicrobial, antifungal, anti-hypertension and anti-parasite. The World Flora Online (https://www.worldfloraonline.org/taxon/wfo-0000519672) provided the taxonomic and morphological description of *Persea americana.* Exclusion criteria: Research papers not published in English, review papers, conference proceedings, abstracts, thesis, and preprint were excluded.

3. Results and Discussion

3.1 Origin, Distribution, And Taxonomy

Avocado (*Persea americana* Mill), commonly known as aguacate, is a tropical fruit native to the Americas. The genus Persea, originally classified as Clus., is a member of the family Lauraceae. Avocados are versatile tree species that are believed to have evolved from a wide geographical region that spannes the eastern and central highlands of Mexico to the Pacific coast of Central America. Although avocados originated in southern Mexico, they are currently grown in countries as distant as Spain, South Africa, and Australia [9-12].

3.2 Biological Activity

The use of therapeutic herbs in alternative medicine has led to the development of several new drugs. More than 80% of the medicine used today was derived from plants in the nineteenth century. The scientific revolution gave rise to the pharmaceutical business, which became well-known for producing pharmaceuticals. Medicinal plants are increasingly used to treat a variety of ailments because they are believed to be safe and effective medications with fewer side effects and a lower cost than conventional treatments. *Persea americana* has been the subject of numerous biological investigations (Figure 1).

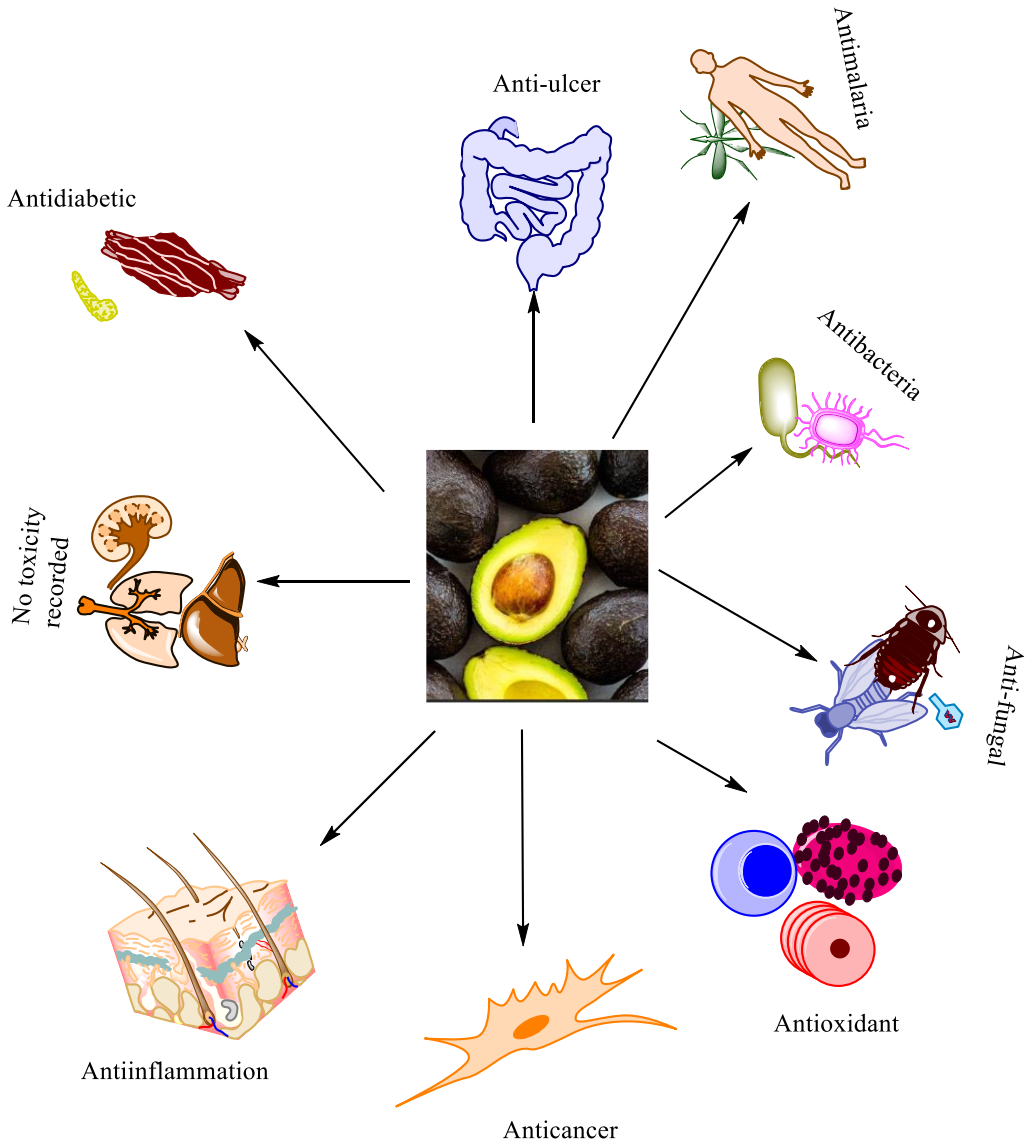


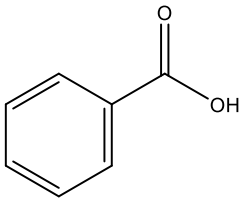
Figure 1: Diseases treated with different parts of *Persea americana* (Source author)

3.2.1 Antioxidant

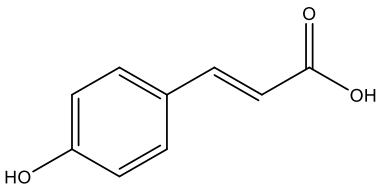
Antioxidants primarily work by preventing free radicals from initiating or advancing oxidizing chain reactions, which delays oxidation of other molecules and reduces oxidative damage [12]. Scientists are putting a lot of time and effort into identifying compounds that could replace synthetic antioxidants, and they are particularly interested in discovering natural sources of antioxidants. Investigating the antioxidant activity of *P. americana* extracts using various experimental methods enables a thorough screening of potential antioxidant pathways. Investigating the antioxidant activity of plant extracts using various experimental methods enables a thorough screening of potential antioxidant pathways. The extracts exhibited a range of 58.50-67.49% inhibition [2]. The seed extract had a value of 2012 ± 300 trolox equivalents/mg for the ability to absorb oxygen radicals [3]. Using the longest sonication period (55 min), showed that the antioxidant activity of the ethanolic avocado seed extract was the highest (158.77 mg Trolox equivalents / g), as evaluated by the oxygen radical antioxidant capacity assay [4]. The extract of the Criollo 6 avocado cultivar showed the best result for inhibiting lipid oxidation, while the Platano Delgado and Criollo 6 avocado cultivars had the highest free radical scavenging activity, with IC_{50} values of 271.86 ± 13.69 and 269.56 ± 6.53 for 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2-Azinobis- 3-ethylbenzothiazolin-6-sulfonic acid (ABTS +), respectively [13]. The IC_{50} value for the antioxidant activity of the methanolic extract of the avocado

peel was 185.891 ± 1.598 ppm [14]. The half-maximal inhibitory concentration (IC_{50}) of DPPH radical elimination was determined to be 0.92 µg/mL, providing evidence of a negative association (the higher the antioxidant activity, the lower the DPPH IC_{50}), with a p-value less than 0.00 [15]. All the studied radicals, including DPPH, showed remarkable free radical scavenging capabilities. Nitric oxide (NO) (IC_{50} = 149.46 µg/mL), hydroxyl (OH) (107.91 ± 3.59 µg/mL), superoxide (O_2) (IC_{50} = 103.05 ± 2.19 µg/mL), and hydroxyl (OH) (107.91 ± 3.59 µg/mL) [16]. With 56.35 mg AAE/100 g, the acetone extract demonstrated a greater reducing power [17]. An analysis of the free radical scavenging activity of DPPH compared to standard ascorbic acid, methanol extracts (IC_{50} = 4.09 µg/mL), petroleum ether (6.12 µg/mL), and ethyl acetate (IC_{50} = 3.42 µg/mL) demonstrated a free radical scavenging efficacy of more than 83%. On the other hand, the antioxidant efficacy of the soluble fraction of petroleum ether was approximately 75% [18]. The experiments with DPPH and Ferric reducing power activity (FRAP) measured the highest antioxidant activity, with Lactiplantibacillus plantarum CECT 9567 achieving 6294.67 ± 19.44 and 6846.91 ± 2.13 µg TE/g d.w., respectively [19]. Silver nanoparticles (Ag NP) exhibited a high level of effectiveness in removing DPPH free radicals, with a rate of 92.02% [20]. According to the DPPH assay technique, the aqueous extract of avocado pulp had slightly stronger antioxidant activity (IC_{50} = 19.32 µg/mL) than the ethanol extract (IC_{50} = 21.84 µg/mL) [21]. In a dose-dependent manner, the seed lipid extract was more inhibitory than the fruit lipid extract. At the maximum concentration of 200 µg/mL, it showed substantial and considerable inhibitory activities against ATBS (69.73%) and DPPH (36.64%), respectively, compared to their comparable standards, Trolox and butylated hydroxytoluene (BHT), which showed inhibitory activities of 122.30 and 113.87% at the same concentration, respectively [22]. Seed extracts had 43% more antioxidant activity in the *in vitro* DPPH • test than skin extracts (35% activity) and fruit pulp extracts (23% activity) [23]. Hydrophilic and lipophilic extracts exhibited comparable trends in DPPH, trolox equivalent antioxidant capacity (TEAC), and oxygen radical absorbance capacity (ORAC) experiments, while lipophilic extracts had greater antioxidant potential. Saturated fatty acids were positively correlated with the DPPH and TEAC tests [24]. In terms of antioxidant activity, supercritical carbon dioxide (CO_2) outperformed compressed LPG by a wider margin: 82.5% suppression of the 1,1-diphenyl-2-picrylhydrazyl radical with CO_2 and 31.6% with LPG [25]. According to DPPH, avocado-peel tea demonstrated antioxidant activity with a value of 1,954.24 ± 87.92 mg of TE L-1 [26]. The antioxidant and antihemolytic properties of the sample were satisfactory. The dissolution capability of bioactive compounds in avocados that are lipid-soluble and ascorbic acid was not significantly different ($p < 0.05$). A weak ferrous ion-chelating activity was observed in the tested material. The antioxidant activity was good, while the ability of the sample to scavenge hydrogen peroxide was modest [27]. There was a concentration-dependent increase in antioxidant activity. Compared to vitamin C and beta-hydroxytryptophan (BHT), avocado fruit extract (1000 µg/mL) scavenged 95% of DPPH and 91.03% of free radicals during the experiment [28]. The peel had the highest antioxidant activity, ranging from 53.3 to 307.3 mmol g - 1 fresh weight [29]. In terms of BHT equivalent / g, avocado epicarp extract had radical scavenging capabilities of 146 g, a-tocopherol of 590 mg, and ascorbic acid of 880 mg [30]. The antioxidant content of avocado seed oil (ASO) is second to that of avocado fruit oil (AFO), which is the highest overall. The IC_{50} values were 50.68 ug/ml for hydroxyl radical scavenging and 62.99 ug/ml for ABTS, respectively [31]. The Hass avocado exhibited the highest DPPH value, measuring 1.3±0.09 µmol TE/g [32]. Of the four fractions examined, fraction III had the highest antioxidant activity, measuring 81.6%, compared to the standard antioxidant ascorbic acid, which recorded 82.3% [33]. In the DPPH assay, the ethanolic extract of the Duke cultivar demonstrated active antioxidant activities with an IC_{50} value of 27.21 µg/ml, but the Fuerte cultivar extract exhibited weaker activity [34]. In vitro tests demonstrated a high % of antioxidant activity for oil seed, ranging from 90.5% to 91.38%. The methanolic fraction exhibited the highest antioxidant activity, at 99.7%, according to the ABTS assay, with an IC_{50} of 0.035 mg / mL [35]. The DPPH free radical scavenging activities of the methanol extracts were much higher than those of the n-hexane extracts. The methanol extracts of the seeds showed the highest activity at 4.17 ± 0.04 mg / mL, while the exocarp showed the second highest activity at 5.25 ± 0.05 mg/mL. Compared to n-hexane extracts, methanol extracts demonstrated superior free radical scavenging capabilities according to the ABTS test. In seed

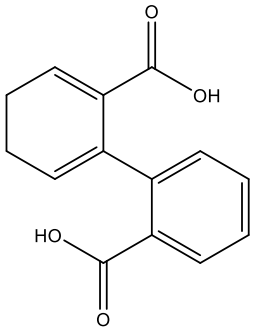
methanol extracts, the highest ABTS free radical scavenging activity was achieved (0.03 ± 0.01 mg / mL) [36]. In contrast to the reference, there was an abundance of the antioxidant enzymes superoxide dismutase (SOD), and glutathione peroxidase (GPx) and catalase (CAT) levels were lower than expected [37]. Outstanding antioxidant capacities were demonstrated as determined by DPPH (128.80 ± 0.0159 µmolTE/L), ORAC (1822.02 ± 12.6338 µmolTE/L), and FRAP (343.88 ± 0.001 µmolAAE/L), respectively [38]. Several studies have linked the antioxidant activity of avocado extracts with specific phenolic compounds (Figure 2), including epicatechin, quercetin, benzoic acid, caffeic acid, chlorogenic acid, ferulic acid, 4-hydroxybenzoic acid, p-coumaric acid. These compounds were also quantified in the present study [39]. Significant antioxidant prowess. The reason for this could be the elevated concentration of total carotenoid components found in the roasted seeds (6534.48 µg/100 g) [40]. Avocado leaves contain phenolic chemicals that have potential as antioxidant agents and as a substitute for conventional food preservation methods [13]. The antioxidant action is due to the complex polyphenols found in the phytochemical material, which includes substances such as alkaloids, saponins, tannins, and flavonoids [14]. Some of the effects could be due to other active substances. The exact amounts of antioxidant activity and the relative roles played by the many chemicals identified are still a mystery. The results of this study raise the possibility that the antioxidant characteristics of these active chemicals may work together or against one another. Therefore, we need to dig deeper to find the standout molecules and learn more about their processes and synergistic effects. The findings of this study clearly demonstrate that *Persea americana* has strong antioxidant properties when tested against several in vitro antioxidant systems. The nutraceutical potential of plant extract lies in its inherent antioxidants, which have the ability to protect cells from oxidative stress.



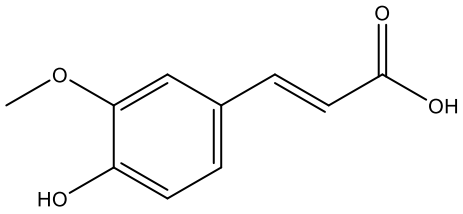
(a)



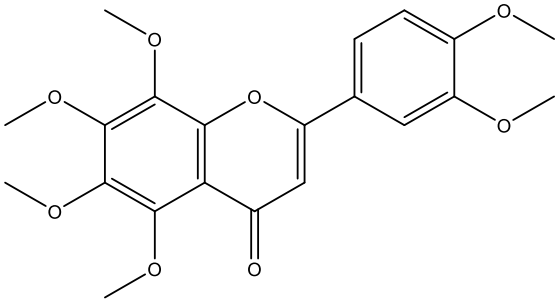
(b)



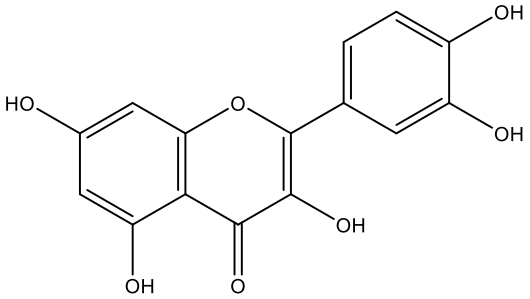
(c)



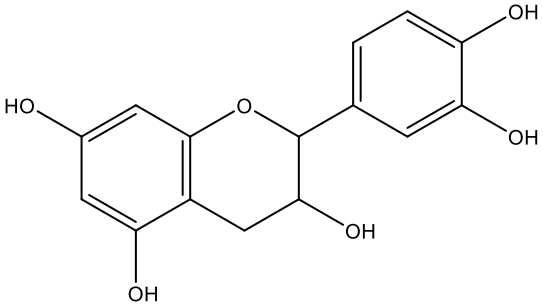
(d)



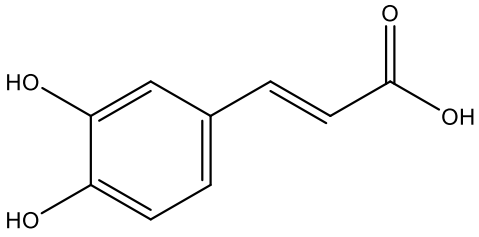
(e)



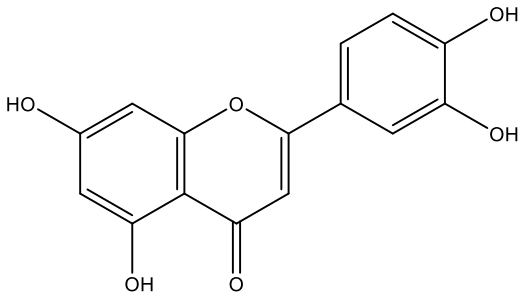
(f)



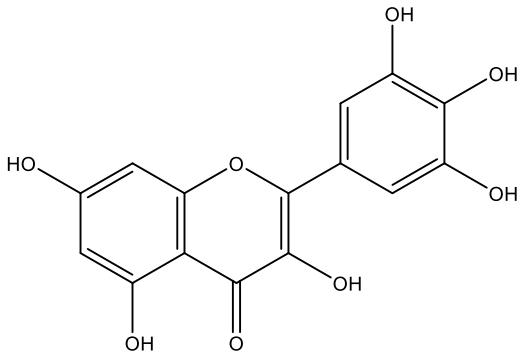
(g)



(h)



(i)



(j)

Figure 2: Major compounds responsible for biological activity; (a) Benzoic acid (b) p-coumaric acid (c) 4-hydrohibenzoic acid (d) Ferulic acid (e) Flavonoid (f) Quercetin (g) Epicatechin (h) Caffeic acid (i) Luteolin (j) Myricetin (Source Author)

3.2.2 Anti-inflammation

To control tissue healing and eliminate foreign substances, infections, or irritants, the body undergoes inflammation [41]. To alleviate symptoms, it is necessary to manage inflammatory reactions; otherwise, significant tissue deterioration or excessive inflammatory responses may occur [42]. Therefore, it is necessary to have substances that reduce inflammation and alleviate pain. By comparing the two components with a standard, we find that their anti-inflammatory effect is dose-dependent (that is, it grows with increasing doses) [22]. After one hour, Duke oil (15 mg/kg) marginally reduced inflammation by 41.12% more than Fuerte oil (15 mg/kg) in the anti-inflammatory paradigm of rat paw edema. The effects of oils on the inhibition of edema were similar after 4 hours, at 35.39% and 34.14% (15 mg/kg), respectively [34]. The anti-inflammatory effect peaked 8 hours after topical treatment of 10 mg/kg; the anti-inflammatory effects were most pronounced, leading to a reduction of 72.28 % in the thickness of the paw with the methanolic fraction and a reduction of 70.8 % with the oil seed. This anti-inflammatory impact was 1.88 times stronger than that of ibuprofen [35]. The antilipid peroxidation assay revealed that methanol seed extracts had the highest activity (7.71 ± 0.36 µg/mL), while exocarp extracts had the second highest activity (12.12 ± 0.34 µg/mL). On the contrary, none of the n-hexane extracts showed any action [36]. At all dosages of infusion, decoction, and avocado peel extract, paw edema was significantly reduced ($p<0.05$) [41]. The edema on the mice's paws is significantly reduced by the methanolic extract of avocado seeds and all levels of infusion. The number of abdominal writhes caused by acetic acid is significantly reduced by all levels of the methanolic extract of avocado seeds, except for the lowest dose of infusion [42]. After 24 hours of treatment with colored avocado seed extract, the production of pro-inflammatory cytokines IL-6, tumor necrosis factor (TNF-α), and interleukin-1 cytokine interleukin-1β (IL-1β) was reduced in RAW264.7 cells activated with LPS. Reductions in NO production and inducible nitric oxide synthase

(iNOS) protein expression occurred in a dose-dependent fashion [43]. Mice with paw edema show a marked improvement after receiving infusions of various dosages and an extract of avocado seeds in methanol [44]. The in vitro anti-inflammatory effect of hydroalcoholic leaf extract was found to be greater. Specifically, hydroalcoholic leaves showed a significant difference in NO release ($p<0.001$) when compared to LPS treatment, TNF-κ release ($p<0.05$) when compared to aqueous and hydroalcoholic leaves, and TNF-α gene expression ($p<0.01$) only when hydroalcoholic leaves were used [45]. The semi-solid formulation containing 50% avocado oil or the group treated with avocado oil showed significant anti-inflammatory action, increased collagen density, and improved tensile strength compared to the control groups [46]. Compared to the acetic acid group, arthroses dramatically reduced both microscopic and gross damage, the study found. Furthermore, arthroses decreased the expression of pNF-kB in rat colon tissue, as well as the activities of myeloperoxidase MPO and TNF-α [47]. The results showed that the inhibition was significantly different between the negative control and the extract at doses of 100, 200, and 400 mg/kgBW ($p<0.05$), but there was no significant difference between the positive control and the extract ($p>0.05$) [48]. Figure 3 illustrates the strong anti-inflammatory therapeutic potential of the extract in an in vitro lipopolysaccharide (LPS)-induced inflammatory paradigm. By preventing NF-κB activation and translocation to the nucleus, it mediated anti-inflammatory effects by preventing the subsequent signaling cascade from creating various inflammatory proteins (Figure 3). Avocado has the potential to enhance collagen production and reduce the presence of inflammatory cells in the wound-healing process. Therefore, it can be regarded as a promising alternative for the treatment of skin wounds.

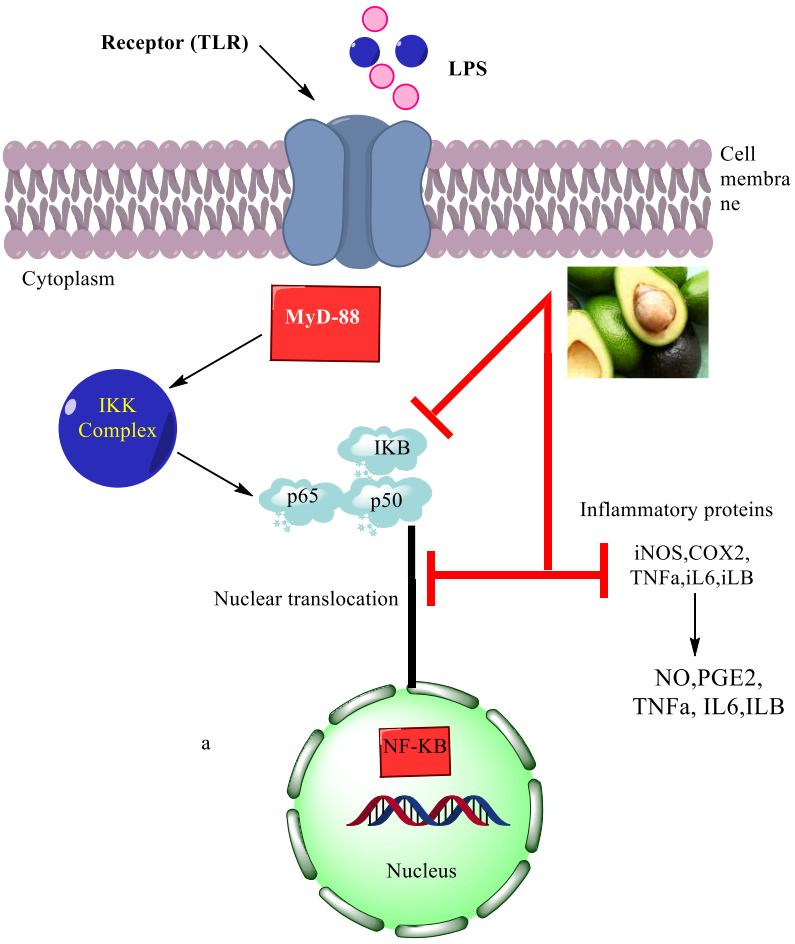


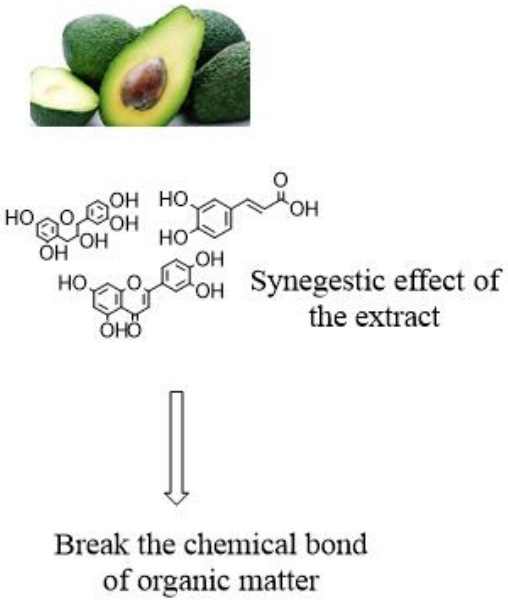
Figure 3: Anti-inflammatory mechanism of action of crude extract of *Persea americana* (Source Author)

3.2.3 Antimicrobials

Antimicrobial resistance is on the rise, synthetic drugs are becoming less effective, and their toxicity is increasing [49]. To combat infectious diseases and the alarming increase in bacteria and other microbes resistant to antibiotics, antimicrobial treatment is an effective technique [50]. Pathogens have become more resistant to traditional antibiotics due to their overuse and improper administration in clinical settings, making these substances less effective in treating infections in humans and animals. Therefore, different approaches to pathogen control are needed. In this regard, the plants present a desirable substitute as a result of their vast array of active antimicrobial chemicals. Therefore, there is a constant need to find new biologically active compounds. The combination of avocado by-product extracts with nisin showed a synergistic impact. The combination of 61% peel extract and 39% nisin produced the strongest antibacterial effect ($p < 0.5$, desirability 0.76) when tested at 1 mg / mL for each component [1]. The extracts have shown inhibitory effects on the growth of all examined bacteria, with a range of 10 to 18 mm [2]. The bacteria strain was neutralized by the inert effects of the negative control, acetone. Avocado extracts were discovered to have varying degrees of antibacterial action, with generally higher levels of efficacy against bacteria [12]. *Aspergillus niger*, resulting in a smaller mycelium at 4.37 mm, 10.32 mm and 11.82 mm, respectively [15]. 9.5 ± 0.5, 12.0 ± 1.21, 7.5 ± 0.35, 6.0 ± 0.5, and 10.0 ± 1.0 were the zone of inhibition reported for *Escherichia coli*, *Klebsiella pneumonia*, Pseudomonas spp., *Staphylococcus aureus*, and Bacillus spp., respectively [16]. At 2000 mg/L, the highest concentration, there was no significant influence ($p < 0.05$) of the solvent used, and the maximum log reductions for *S. aureus* and *S. Typhimurium* were 4.0 ± 0.3 and 1.8 ± 0.3, respectively [17]. The extracts of petroleum ether, ethyl acetate, and methanol each had an activity range of 0.8 to 30 mm against six different bacterial species: *E. coli, Pseudomonas aeruginosa, Salmonella typhi, Staphylococcus aureus,* and *Klebsiella pneumoniae* [18]. The sample had a significant antibacterial effect against *Candida albicans*, as evidenced by a zone of inhibition of 26 mm [20]. The agar well diffusion method showed that all pulp extracts were active against five different bacteria species. *Bacillus subtilis, Staphylococcus aureus, Bacillus pumilus*, *Candida albicans*, and *Escherichia coli*. However, no extract was active against *Pseudomonas aeruginosa* [21]. The zone of inhibition against *Bacillus subtilis* and *Staphylococcus aureus* was greatest at a concentration of 50 µl in fractions III and IV [33]. The ethanolic seed extract proved to be the superior antibacterial. At very high concentrations, the efficiency was 80% and 100%, respectively [49]. In lower quantities, there was no inhibition [49]. At a concentration of 100 µg/mL, the viability of *E. coli* clones (>55%) was suppressed. At 50 µg/mL total protein, S. aureus viability decreased to a lesser extent (27–38%), but at 100 µg/mL, it was more noticeable (52–65%) [50]. Extracts with the best minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) values were generated from the peel of the Quintal variety, with 0.625 mg mL-1 for the MIC test and 2.5 mg mL-1 for MBC against the bacteria *S. aureus* [51]. The essential oils of the Bacon cultivar had the strongest effect against *S. typhimurium* (IC_{50} 0.9 l / mL compared to 0.98 µg/mL for ciprofloxacin) and *S. aureus* (IC_{50} 21 l / mL compared to 1.95 µg/mL for ciprofloxacin) [52]. At 37 and 4 ° C, extracts and two isolated acetogenins exhibited bactericidal action, with minimum inhibitory concentration (MIC) values ranging from 7.8 to 15.6 mg/L [53]. At doses of 0.1 and 0.4 g/mL, respectively, *P. aeruginosa* had the largest zones of inhibition, measuring 12.00 and 30.00 mm. At doses ranging from 0.1 to 0.4 µg/mL, the inhibition zones for *S. aureus* ranged from 10.00 to 20.00 mm in diameter. The inhibitory zones for *E. coli* at doses of 0.1 and 0.4 g/mL were 10.00 and 15.00 mm in diameter, respectively. Zones of inhibition for *Candida albicans* ranged from 8.00 to 13.00 mm at concentrations of 0.1 to 0.4 g / mL, while for *S. pneumonia*, the range was 8.00 to 12.00 mm at the same concentrations [54]. Except for Escherichia coli, ethanol extracts exhibited antimicrobial activity (104.2-416.7 µg/mL) against both Gram-positive and Gram-negative bacteria. In contrast, water extracts inhibited the growth of Listeria monocytogenes (93.8-375.0 µg/mL) and *Staphylococcus epidermidis* (354.2 µg/mL)

[55]. The methanol extract was more effective against *P. aeruginosa* (30 mm) and *St. aureus* (20 mm); on the other hand, the hot water extract was better at killing *P. aeruginosa* (20 mm) and *E. coli* (14 mm). The four extracts worked better on *P. aeruginosa* than on the other germs. There was no statistically significant difference between the antimicrobial activity of the extracts and that of other standard antimicrobials ($p < 0.05$) [56]. The antibacterial activity against *C. sporogenes* endospore germination was demonstrated by AcO-avocadenyne (1), one of the acetogenins recently identified by our lab. However, inhibitory zones were greatest for AcO-avocadene (2) [57]. MICs of 125 µg/mL against the H37Ra strain and 62.5 µg/mL against the H37Rv strain, respectively, showed that the extracts of *P. americana* were very active against these mycobacteria strains [58]. The minimum inhibitory concentrations of the hexane extract for Candida spp., *Cryptococcus neoformans* and *Malassezia pachydermatis*, respectively, ranged from 0.625 to 1.25 mg L^{-1}, 0.312 to 0.625 mg mL^{-1}, and 0.031 to 0.625 mg mL^{-1}. The extracts were also active against all yeast strains tested in vitro, although the results varied. Candida spp., *Cryptococcus neoformans*, and *Malassezia pachydermatis strains* had minimal inhibitory concentrations for the methanol extract ranging from 0.125 to 0.625 mg mL-1, 0.08 to 0.156 mg mL^{-1}, and 0.312 to 0.625 mg mL^{-1}, respectively [59]. At 6.25 mg / mL, the extract had a MIC, and at 12.5 mg/mL, all planktonic cultures were killed. Biofilms, doses of 50 (log10), 100 (log10), and 200 mg/mL (log10) significantly reduced biofilm [60]. *Botryodiploidia theobromae* (13.20), *Rhizopus stolonifera* (14.02), A. flavus (12.10), *Fusarium oxysporum* (9.30) and *Germinia candidum* (7.00) were the fungal pathogens tested for antifungal activity. The results indicated varying degrees of inhibition in each [61]. The seed extract demonstrated antibacterial activity (mm) against *Pseudomonas aeruginosa* (15±0.11), *Staphylococcus aureus* (16±0.04), *and Proteus mirabilis* (23±0.14), but at a lower level than that of the reference drug, Ciprofloxacin [62]. Compared to avocado peel extract, which had an inhibitory effectiveness of up to 750 µg/mL against *Escherichia coli* and Salmonella spp., the fraction showed an increase of up to 25% and an increase of 83.34% against L. monocytogenes, respectively, at a MIC of 125 µg/mL [63]. The phytopathogens *Colletotrichum gloeosporioides* and *Fusarium oxysporum*, as well as the human infections *Candida albicans* and *C. glabrata*, were all inhibited by the antifungal activity of the recombinant peptide at a concentration of 200 µg/mL [64]. With diameters of 38.16 and 26.94 mm for *L. monocytogenes*, and 26.17 and 19.90 mm for other bacteria, ethanolic extracts were prepared from fresh and dried seeds, and inhibited growth to a level comparable to a positive control [65]. Even after 72 hours of exposure, the composite film did not show cytotoxicity to L929 cells and showed strong antifungal activity against mold (*Aspergillus flavus* and Colletotrichum orbiculare) [66]. At a concentration of 75 µL, the gram-positive bacteria *Streptococcus* showed the largest zone of inhibition measuring 22.23 ± 0.15 mm, while the *Rhizobacterium* bacteria showed the smallest zone of inhibition measuring 9.27 ± 0.15 mm at a dose of 25 µL [67]. Except for *Staphylococcus aureus*, the inhibition zones of acetogenins against Gram-positive bacteria were two to four times greater than those of Nisaplin and Mirenat. Infections caused by bacteria and fungi, including wound and skin infections, sepsis, and endocarditis, can be controlled by the plant [68]. In terms of zone of inhibition, the ethanolic extract showed the highest value (14.0 mm) against *Salmonella typhi* and the lowest value (8.00 mm) against *Escherichia coli*. In terms of aqueous extract, *Escherichia coli* showed the smallest zone of inhibition at 6.0 mm and *Salmonella typhi* the largest at 16.00 mm [69]. The results show that the avocado bark ethyl acetate extract has strong antimicrobial effects against four different test species, including *E. coli, Bacillus pumilus, Staphylococcus aureus*, and *Candida albicans,* with inhibitory concentrations ranging from 10 to 20 mm [70]. *Staphylococcus aureus* was inhibited by a 1.8 mm halo at a concentration of 7 mg/mL of solvent extracted extract [71]. The antibacterial activity of the ethanol extract was limited to a subset of human-origin isolates of *S. agalactiae.* All strains of *S. agalactiae,* regardless of their source, were inhibited by the dichloromethane extract [72]. All microorganisms tested were susceptible to the antibacterial effects of the ripe avocado peel extract. A MIC of 4.375 εg/mL was found for *S.*

aureus and MRSA, the lowest MIC, while the reference strains of *P. aeruginosa* exhibited the highest MIC, measuring 8.75 µg/mL [73]. The MIC for *S. epidermidis* was 50 µg/mL, indicating that the acetone extract was the most effective of the extracts tested. The ethanol: water extract maintained 18% viability of *K. pneumoniae* cells at 100 µg/mL [74]. According to the results, *Penicillium notatum* (42.40 mm), *Pseudomonas aeruginosa* (35.30 mm), *Escherichia coli* (27.25 mm), *Enterococcus faecium* (23.21 mm), *Enterococcus faecalis* (21.20 mm) and *Aspergillus niger* (20 mm) were successfully treated with the extract of seeds and peels. Even at the highest dose tested, the peel extract could not suppress *Aspergillus niger* [75]. It is possible that differences in membrane structure explain why antibacterial activity was greater against Gram-positive bacteria, such as *S. aureus*, compared to Gram-negative bacteria [51]. Gram-negative bacteria have a multilayered structure and an outer membrane made of lipopolysaccharides. Their cell walls have a higher lipid content, which means that they interact less with the extracts [51]. This variation in effectiveness could be because the essential oil blend contains both oxygenated (estragole and methyl eugenol) and non-oxygenated (α-pinene and alpha-pinene), which can have either a synergistic or antagonistic effect [52]. Lytic actions and enhanced membrane permeability likely cause a bactericidal effect [53]. The active components found in avocado seed extract, including polyphenols, condensed tannins, phenolic acids, and flavonoids, are responsible for the inhibition of bacterial growth observed [76]. Because this chemical was able to reduce ROS creation in both *A. nigger* and *Phytophthora cinnamomi*, it appeared that its antibacterial action correlated with its antioxidant activity [77]. The bioactive chemicals included in the extract may be responsible for its notable antibacterial effects. Bioactive compounds exhibit their antimicrobial properties through various mechanisms, including membrane disruption, protein binding, enzyme inhibition, substrate deprivation, and metal ion complexation (Figure 4) [54]. Alternatively, they can interfere with essential microbial processes such as deoxyribonucleic acid (DNA) replication and ribonucleic acid (RNA) transcription [54]. Therefore, the variations in results could be explained by the different extraction techniques, region of plant collection, and solvents employed in each study. Infections caused by bacteria and fungi can be controlled by plant extract. According to the studies presented in this article, crude extracts of avocados contain antimicrobials and have the potential to be used as antibiotics.



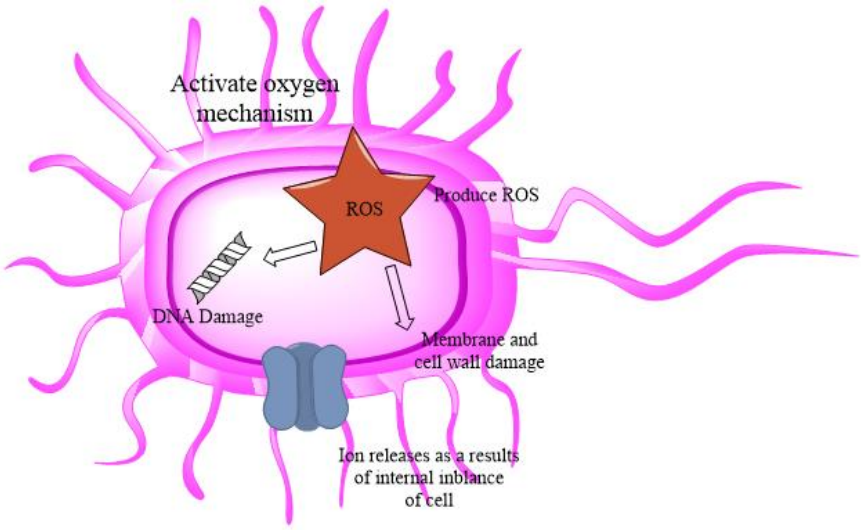


Figure 4: Mechanism of action of Persea americana on bacteria (Source author)

3.2.4 Antiparasites and Antiarthritic

Parasite-caused infections are a big concern in public health because they can make people sick or even die [78, 79]. Drug resistance, drug residues, and unwanted side effects are some of the problems with using chemical medications to combat parasites. However, these therapies are effective when used properly. The insect has a lethal concentration (LC50) of 30.28 µg/mL and has strong larvicidal effects against Aedes aegypti mosquitoes [20]. Larvicidal activity against An. stephensi was strongest against all three compounds; avocadene had an LC50 value of 2.80 ppm, avocadyne of 2.33 ppm, and avocadenol-A of 2.07 ppm. With a concentration of 3.73 ppm against Aedes aegypti and 5.96 ppm against Cx. quinquefasciatus, the avocado showed larvicidal action. For A. aegypti, the value of LC50 avocadyne was 5.35 ppm, and for Cx. quinquefasciatus it was 3.98 ppm. The results against A. aegypti and Cx. quinquefasciatus were 6.56 ppm and 2.35 ppm, respectively, for avocadenol-A [80]. The optimal dosage of the extract was 500 mg/kg, which resulted in a marked decrease (by approximately 85.41 %) in the output of oocysts in mouse urine, a reduction (by approximately 20%) in the number of stages of parasite development, and an increase (by approximately 20%) in the number of goblet cells in the jejunal tissues [81]. The extract demonstrated significant antiarthritic activity in rats, which reduced inflammation volume, improved antioxidant status in arthritic rats (as indicated by lower plasma levels of malondiadehyde), increased antioxidant enzymes (SOD, catalase, and glutathione peroxidase), and decreased the inflammatory marker TNF-α. Histopatological examinations of joint tissue from arthritic rats revealed a substantial improvement after using the extract [82].

3.2.5 Anti-diabetic

A global epidemic, diabetes, affects millions of people. Reducing postprandial hyperglycemia by blocking digestive carbohydrate hydrolysis enzymes is the gold standard treatment for diabetes right now [28]. According to the World Health Organization, the number of adults with diabetes is expected to reach 300 million by 2025 [9]. This makes diabetes a major concern for human health in the 21st century and the fifth leading cause of death in developed nations [83]. A variety of bioactive chemicals found in plant extracts have shown promise in the treatment of diabetes. The antidiabetic activity was best in Lactiplantibacillus plantarum CECT 748T, with inhibition of the alpha-amylase activity of 52.15% ± 0.67% [19]. The fruit extract had a greater inhibitory effect against α-amylase (92.13% inhibition) compared to the leaf extract (88.95% inhibition) at a concentration of 1000 µg/mL [28]. The time-dependent and dose-dependent inhibitory effect on the α-glucosidase enzyme was best exhibited by the methanolic extract [74]. Compared to positive controls, in vitro studies demonstrated

that an aqueous seed extract was effective against free radicals and had the ability to inhibit enzymes. Significantly reduced the increases in FBG, TG, LDL-c, G6P, F-1, 6-BP, MDA, IL-6, TNF-α, and NF-B that were caused by alloxan while further increasing the decreases in liver glycogen, hexokinase, and HDL-c that were caused by alloxan [84]. On day 28, all extracts (100 mg/kg/day, orally) considerably ($p<0.001$) decreased blood glucose levels ($p <0.001$), with the methanolic extract showing the most noticeable impact. Both T-CHOL and HDL-C levels were restored in the treatment group compared to the control group, and the therapies were well tolerated [85]. Compared to the placebo group, those given any dosage of the extract had a markedly lower blood glucose level. Compared to the control group, those given the higher dose (500 mg/kg) had much lower levels of total cholesterol, triglycerides, and low-density lipoproteins. Furthermore, HDL cholesterol saw a small increase [83]. The hydroalcoholic extract of Persea americana leaf improved the metabolic status and decreased blood glucose levels in rats. The liver and skeletal muscle of treated rats showed PKB activation compared to untreated rats [86]. All groups saw a notable drop in blood glucose levels ($p<0.001$) as compared to Group II. Blood glucose levels increased significantly rose ($p<0.05$) a week after the discontinuation of the extract. Groups III, IV, and V all showed a notable increase in body weight compared to group II, with p values less than 0.01, 0.001, and 0.05, respectively [87]. Lactiplantibacillus plantarum exhibited the most potent antidiabetic effect, with a significant suppression of alpha-amylase activity at a rate of 52.15% ± 0.67% [88]. A single dose of the extract, as well as sustained therapy for seven days, resulted in a dose-dependent decrease ($p < 0.01$) in blood glucose level (BGL) in alloxan-diabetic rats when administered an aqueous extract of P. americana (100-200 mg / kg), compared to the control group. At 6 hours after the first dose of the extract, the highest degree of antidiabetic action was achieved, leading to a 60.02 ± 6.83% decrease in blood glucose levels [89]. In a pattern that depended on the dose, the extracts of leaves, peel, flesh, and seeds reduced the activities of α-amylase, α-glucosidase, and malondialdehyde formation. The α-amylase and α-glucosidase inhibitory activities of -amylase and -glucosidase were observed most strongly in the peel, as shown by the highest significant ($p < 0.05$) IC50, the lowest extract concentration required to inhibit 50% enzyme activity [90]. A substantial increase in HDL-c was observed ($p <0.05$) in the group that received a powdered extract of mango and avocado seeds, compared to the control group. Furthermore, kidney and liver functions improved, and alanine transaminase (ALT), aspartate transaminase (AST), alkaline phosphatase (ALP), serum glucose, creatinine, uric acid, and urea decreased [91]. The regeneration of pancreatic cells in white male rats was affected by an ethanolic extract of avocado leaves at a dose of 100 mg/kg of body weight (a score of 1.67). A score of 1.00 at 150 mg/kg body weight (bw) and a score of 0.33 at 200 mg/kg indicate that the improvement in pancreatic cell regeneration increases according to the dosage [92]. The findings demonstrated that the extract had a similar impact to glibenclamide in reversing histopathological damage in alloxan-induced diabetic rats and a substantial hypoglycemic effect ($p < 0.05$) [93]. Mice fed avocado (1.960 g / kg bw) had a 64.27% reduction in glucose levels. Compared to patients given glipizide (68.50%), the efficacy of this treatment was statistically insignificant [94]. Concentrations of all blood sugar levels decreased after administration of extracts of avocado seeds. At 300 mg/kg of bw extract, the greatest reduction in blood sugar level was observed [95]. Compared to the control group, rats that were hyperglycemic due to streptozotocin (STZ) had a greater % change in body weight, increased food intake and fecal output, and decreased water intake and urine output after both acute and chronic administration of HWE-PA. The effects of hot water extract of stem bark animal extracts of P. americana (HWE-PA) on STZ-induced hyperglycemic rats were observed in their body weight, food intake, fecal output, water intake, and urine output. This enhancing effect was observed after acute and chronic administration of HWE-PA [96]. Anti-diabetic properties linked to polyphenols [19]. The flavonoid component myricetin has been found to possess antioxidant and anti-diabetic properties. The metabolic activity of insulin was aided by myricetin, which stimulated phosphatidylinositol 3-kinase (PI3K) and its effectors

(Figure 5) [84]. The presence of hypoglycemic agents, steroids, alkaloids, tannins, and saponins in the extract of P. americana results in its significant antidiabetic activity [83]. One possible way that the extract modulates glycolipid metabolism and improves insulin sensitivity is by activating the PI3K/AkT pathway and inhibiting β-cell death, which can be achieved by its administration [84]. Like the reference drug glipalamide metformin, the plant extract protected the pancreas, kidneys, and liver (Figure 5). The extracts lower the atherogenic index of plasma, which in turn lowers the risk of cardiovascular problems. The findings of this review provide credence to the traditional use of P. americana as a pharmacological tool in the fight against diabetes.

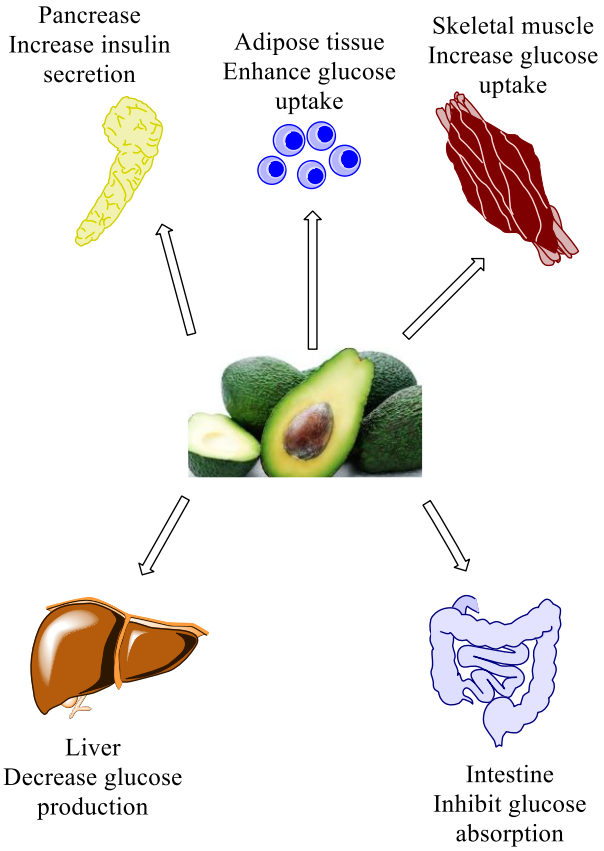


Figure 5: Mechanism of action of Persea americana against diabetes (Source author)

3.2.6 Anticancer

Uncontrolled and misdirected cell division is the cause of cancer. Approximately 14 million new cases of cancer were recorded worldwide in 2012, and 8.2 million people died from cancer-related causes [97]. Medicinal plants have helped to grow and spread the modern healthcare system. With their increasing acceptance and recognition around the world, medicinal plants continue to be the only viable option. Seed extract of various colors was found to have a dose-dependent effect on the viability of human cancer cells in vitro, specifically MCF7, H1299, HT29, and LNCaP. After 48 hours of treatment, the half-maximum inhibitory concentrations varied between 19 and 132 µg/mL. The expression of cyclin E2 and D1 was negatively regulated in LNCaP cells when treated with extract [3]. Compared to the reference drug sorafinib, these data demonstrate that lipid extracts from seeds and fruits significantly inhibit HepG2 and HCT116 cell lines of hepatocellular carcinoma and colon cancer, respectively. In contrast to the other groups, seed lipids had a very noticeable inhibitory effect on both cell lines [22]. Efficaciously converted 4-nitrophenol (4-NP) into 4-aminophenol and dose-dependently decreased Caco-2 and PC-3 cell viability [38]. Exhibited significant inhibitory effects on the growth of Hs27 and DLD-1 cell lines [40]. Hepatocellular carcinoma cells (HEPG2), breast

adenocarcinoma (MCF7), and colorectal cancer cells (HT29) were tested with an IC_{50} of 8.1, 52.1, and 11.3 µg/mL, respectively, of the extract [82]. Therapies reversed the decline in glutathione content and activity in liver tissues, as well as the increase in lipid peroxidation and improved glutathione-S-transferase and superoxide dismutase levels [98]. Both the soluble fraction of methanol (FLM) and the nonsoluble fraction of methanol (FTLM) showed enhanced cytotoxic activity against MCF-7 cell lines, with IC_{50} values of 34.52 and 66.03 µg/mL, respectively [99]. The IC_{50} values for the MCF-7 and HepG2 cell lines were 62 µg/mL and 12 µg/mL, respectively, and the compound was safe for use with normal cells while inhibiting cell proliferation [100]. When tested in various cancer cell lines, including Hep G2, MDA-MB-231, and MCF-7, the seed powder demonstrated the most potent inhibitory effect [101]. The results demonstrated that, compared to normal cells, avocado fruit extract effectively inhibits cancer cell proliferation of cancer cells ($P<0.05$) [102]. IC_{50} = 141.62 µg/mL was the dose at which PaDef began to decrease the viability of MCF-7 cells [103]. The growth of androgen-dependent cancers (LNCaP) and androgen-independent cancers (PC-3) was inhibited by an avocado acetone extract that contained these carotenoids and tocopherols cultured prostate cancer cells [104]. The extract was most effective at a concentration of 200 mg/kg body weight, while it was also beneficial at 100 mg and 150 mg/kg body weight. Significant levels of numerical and structural abnormalities (such as breaks and premature centromeric division) were reduced (up to 88%, $p < 0.0001$), as was an acrocentric association (up to 78%, $p = 0.0008$) within the D & G group [105]. In malignant tissues, adenosine deaminase (ADA) activities were noticeably higher than in non-cancerous control tissues ($p<0.001$). A considerable increase in ADA activity was observed in malignant tissues ($r=0.93$, $p <0.001$) compared to non-cancerous tissues ($r=0.60$, $p=0.029$) when avocado leaf extract was used [106]. In an oxidative stress-dependent manner, and through mitochondrial membrane depolarization (52.8–87%), activation of transcription factor p53 (6.3–25.4%), protease caspase-3 (8.3-20%), and predominance of AIF reactivity (20.6-36%), endocarp, seed, whole seed and leaf extracts (0.1 mg/mL) significantly induced apoptosis in Jurkat cells ($p < 0.001$) in all extracts. Results were also achieved using extracts at a concentration of 0.5 mg/mL. However, 100% necrosis was caused at an extract concentration of 1 mg / mL or more [107]. The concentration-dependent cytotoxicity of the lipid-rich extract against D-17 cells was measured at 15.5 µg/mL [108]. The existence of various polyphenols and their cooperative impact should be connected to the outcome [109]. Consumption of fruits has been found to provide protection against several forms of cancer, neurological problems, and chronic diseases in humans [23]. Plant extracts not only boost survival signaling pathways and disrupt pro-apoptotic intermediates but also decrease apoptosis (Figure 6). One important step towards metastasis is the angiogenesis pathway, which bioactive chemicals can influence. This process involves the formation of blood vessels within the tumor.

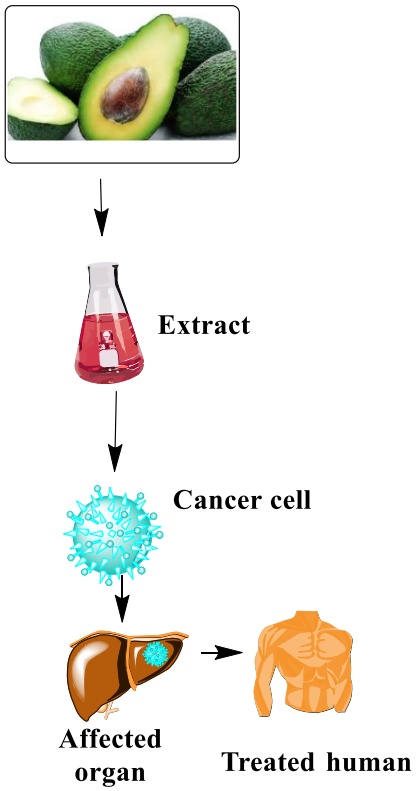


Figure 6: Mechanism of action of Persea americana against cancer cells (Source author).

3.2.7 Other Diseases

Antiulcer: The extract inhibited indomethacin-induced histological alterations and the spread of ulcers and lesions (92% protection) [109]. Anticonvulsant: Like the reference anticonvulsant drugs, the aqueous extract of Persea americana leaves (PAE, 100-800 mg / kg ip) considerably ($p < 0.05$-0.001) slowed the start of seizures and counteracted the effects of seizures caused by pentylenetetrazole (PTZ). Furthermore, picrotoxin (PCT)-induced seizures were significantly reduced by the plant leaf extract (PAE, 100-800 mg / kg ip), while bicuculline (BCL)-induced seizures were only mildly reduced [110].

3.2.8 Toxicity Evaluation

Before incorporating plant extracts into human cosmetic, pharmaceutical or alimentary products, it is necessary to perform toxicological and genotoxic evaluations to ensure their safety [111]. A large body of research indicates that medicinal plants include a diverse range of chemicals with beneficial biological effects [112]. These components must be safe or have low toxicity levels to have any value [9]. The toxicity of the components of the extract of P. americana has been the subject of numerous research. The extract has an LC50 value of 204.95 mg mL-1 when tested for toxicity against A. salina using linear regression. An extract is deemed dangerous if its lethal concentration (LC50) result is below 1000 µg mL/mL, and nontoxic if it exceeds this threshold. Thus, it was determined that this extract did not have any harmful effects on A. salina since its LC50 level was 204.95 mg ml / mlmL/mL [51]. LC50 values for avocado seed extracts with hexane and methanol were 2.37 and 24.13 mg ml / mL, respectively, against Artemia salina. LC50 values for the hexane and methanol extracts against Aedes aegypti larvae were 16.7 and 8.87 mg ml / mL, respectively [59]. For macrophages, doses of 200 and 100 mg / mL were cytotoxic, but 50, 25, and 12.5 mg / mL demonstrated viability levels greater than 55% [60]. Wistar rats did not show any signs of toxicity even after receiving extremely high doses when tested for acute toxicity. As a result, 10 g/kg body weight was established as the

maximum tolerated dose (MTD) [113]. In the micronucleus test, the frequency of the micronuclei was not different between the vehicle control group and the groups treated with avocado seed extract, suggesting that the extract did not exhibit any genotoxic activity [111]. The study findings indicate that the extract does not have any toxicological consequences. The assessment of the toxicity level of each ingredient is the cornerstone of any medicinal or herbal formulation. While animal studies have demonstrated the safety of avocado extract, the human dosage and potential side effects must be considered before considering it effective and safe for human ingestion.

3. Conclusions

Numerous biological processes have already been the subject of preclinical research. The reason for the significant biological activity observed in all parts of the plant is the high concentration of polyphenol compounds. The results of the review showed that because avocados are high in polyphenols, they have significant potential to improve human health. The review can be used well for new scientific and developmental studies. The research findings show promise; it is crucial to note that this study was carried out on experimental animals. The findings presented in this study provide a foundation for much-needed future research. Future research endeavors will prioritize the comprehensive examination of the following topics: (1) identification of species through micromorphology and anatomy on a global scale; (2) determination of the mechanism of action of the separated components; (3) carrying out a clinical trial; (4) determination of the standard dosage and safety of the extract; and (5) preparation of herbal medicine utilizing all parts of the plant.

4. Authors' Contributions

Developed the concept, conducted research, assessed the results, and wrote the article.

5. Conflict of Interest

Not applicable

6. Acknowledgments

We express our appreciation to Dr. Ibrahim Gambo for his scientific contributions, as well as to Dr. Razika Muhammad Shafiu for proofreading the English language.

Reference

[1] Calderón-Oliver, M., H.B. Escalona-Buendía, O.N. Medina-Campos, J. Pedraza-Chaverri, R. Pedroza-Islas& E. Ponce-Alquicira, Optimization of the antioxidant and antimicrobial response of the combined effect of nisin and avocado byproducts. LWT-Food Science and Technology. 2016, 65: 46-52. https://doi.org/10.1016/j.lwt.2015.07.048.

[2] Kupnik, K., M. Primožič, V. Kokol, Ž. Knez& M. Leitge E. Enzymatic, Antioxidant, and Antimicrobial Activities of Bioactive Compounds from Avocado (Persea americana L.) Seeds. Plants. 2023, 12(5): 1201. https://doi.org/10.3390/plants12051201.

[3] Dabas, D., R.J. Elias, G.R. Ziegler& Lambert, J.D. In vitro antioxidant and cancer inhibitory activity of a colored avocado seed extract. International Journal of Food Science. 2019. https://doi.org/10.1155/2019/6509421.

[4] Tan, C.X., R. Chin, S.T. Tan & Tan, S.S. Phytochemicals and antioxidant activity of ultrasound-assisted avocado seed extract. Malaysian Journal of Analytical Sciences. 2022, 26: 439-446.

[5] Yasir, M., S. Das & Kharya, M. The phytochemical and pharmacological profile of Persea americana Mill. Pharmacognosy reviews. 2010, 4(7): 77-84. https://doi.org/10.4103/0973-7847.65332.

[6] Ranade, S.S. & Thiagarajan, P. A review on Persea Americana Mill. (Avocado)-Its fruit and oil. International Journal of PharmTech Research. 2015, 8(6): 72-77.

[7] Ochoa-Zarzosa, A., M. Baez-Magana, J.J. Guzman-Rodriguez, L.J. Flores-Alvarez, M. Lara-Márquez, B. Zavala-Guerrero, R. Salgado-Garciglia, R. Lopez-Gomez& López-Meza, J.E. Bioactive molecules from native Mexican avocado fruit (Persea americana var. drymifolia): a review. Plant Foods for Human Nutrition. 2021, 76: 133-142. https://doi.org/10.1007/s11130-021-00887-7.

[8] Ashande, C.M., G.L. Lufuluabo, J. Mukiza& P.T. Mpiana, A mini-review on the Phytochemistry and Pharmacology of the medicinal plant species Persea americana Mill. (Lauraceae). Discovery Phytomedicine. 2019, 6(3): 102-111. https://doi.org/10.15562/phytomedicine.2019.99.

[9] Abdulrahman, M.D., A.M. Zakariya, H.A. Hama, S.W. Hamad, S.S. Al-Rawi, S.W. Bradosty& Ibrahim, A.H. Ethnopharmacology, biological evaluation, and chemical composition of Ziziphus spina-christi (L.) Desf.: A Review. Advances in Pharmacological and Pharmaceutical Sciences. 2022. https://doi.org/10.1155/2022/4495688.

[10] Dogara, A.M., A systematic review on the biological evaluation of Calotropis procera (Aiton) Dryand. Future Journal of Pharmaceutical Sciences. 2023, 9(1): 1-16. https://doi.org/10.1186/s43094-023-00467-3.

[11] Dogara, A.M. Biological activity and chemical composition of Detarium microcarpum Guill. and Perr—a systematic review. Advances in Pharmacological and Pharmaceutical Sciences. 2022, 2022. https://doi.org/10.1155/2022/7219401.

[12] Rodríguez-Carpena, J.-G., D. Morcuende, M.-J. Andrade, P. Kylli & Estévez, A.M (Persea americana Mill.) phenolics, in vitro antioxidant and antimicrobial activities, and inhibition of lipid and protein oxidation in porcine patties. Journal of agricultural and food chemistry. 2011, 59(10): 5625-5635.

[13] Castro-López, C., I. Bautista-Hernández, M.D. González-Hernández, G.C. Martínez-Ávila, R. Rojas, A. Gutiérrez-Díez, N. Medina-Herrera & Aguirre-Arzola,V.E. Polyphenolic profile and antioxidant activity of leaf purified hydroalcoholic extracts from seven Mexican Persea americana cultivars. Molecules. 2019, 24(1): 173. https://doi.org/10.3390/molecules24010173.

[14] Rahman, N., S.M. Sabang, R. Abdullah & Bohari,B. Antioxidant properties of the methanolic extract of avocado fruit peel (Persea americana Mill.) from Indonesia. Journal of Advanced Pharmaceutical Technology & Research. 2022, 13(3): 166. https://doi.org/10.4103/japtr.japtr_22_22.

[15] Skenderidis, P., S. Leontopoulos, K. Petrotos, Mitsagga C & Giavasis, L.The in vitro and in vivo synergistic antimicrobial activity assessment of Vacuum Microwave Assisted aqueous extracts from pomegranate and avocado fruit peels and avocado seeds based on a mixtures design model. Plants. 2021, 10(9): 1757. https://doi.org/10.3390/plants10091757.

[16] Kamaraj, M., V. Dhana Rangesh Kumar, Nithya, T. & U. Danya, U. Assessment of antioxidant, antibacterial activity and phytoactive compounds of aqueous extracts of avocado fruit peel from Ethiopia. International Journal of Peptide Research and Therapeutics. 2020, 26: 1549-1557. https://doi.org/10.1007/s10989-019-09965-6.

[17] Soledad, C.P.T., H.C. Paola, O.-V.C. Enrique, R.-L.I. Israel, N.-M. GuadalupeVirginia& Raúl, Á.S. Avocado seeds (Persea americana cv. Criollo sp.): Lipophilic compounds profile and biological activities. Saudi journal of biological sciences. 2021, 28(6): 3384-3390. https://doi.org/10.1016/j.sjbs.2021.02.087.

[18] Sudhasupriya, P., A.S. Begam& Rajeshkumar, S. Screening for antioxidant and antimicrobial activity of seed extracts of avocado pear. Research Journal of Pharmacy and Technology. 2017, 10(6): 1991-1996. https://doi.org/10.5958/0974-360X.2017.00348.1.

[19] Razola-Díaz, M.d.C., S. De Montijo-Prieto, M.J. Aznar-Ramos, M. Jiménez-Valera, A. Ruiz-Bravo, V. Verardo& Gómez-Caravaca, A.M. Effect of Lactic Acid Bacteria Fermentation on the Polar Compounds Content with Antioxidant and Antidiabetic Activity of Avocado Seed Extracts. Fermentation. 2023, 9(5): 420. https://doi.org/10.3390/fermentation9050420.

[20] Nallal, V.U.M., Prabha K & Razia, M. Avocado-waste mediated synthesis of Silver nanoparticles and exploration of their potential biological properties. Materials Today: Proceedings. 2022, 64: 1745-1749. https://doi.org/10.1016/j.matpr.2022.05.537.

[21] Moe, S. & Ngon, E.T. Fatty Acids In Avocado Oil And Nutritional, Antioxidant And Antimicrobial Assessment of The Pulp. Journal of Myanmar Academic Arts and Science.2020, XVIII.(1B): 212-224.

[22] Alkhalaf, M.I., W.S. Alansari, Ibrahim E.A & ELhalwagy, M.E. Anti-oxidant, anti-inflammatory and anti-cancer activities of avocado (Persea americana) fruit and seed extract. Journal of King Saud University-Science. 2019, 31(4): 1358-1362. https://doi.org/10.1016/j.jksus.2018.10.010.

[23] Ferreira da Vinha, A., J. Moreira & Barreira,S. Physicochemical parameters, phytochemical composition and antioxidant activity of the algarvian avocado (Persea americana Mill.). Journal of Agricultural Science. 2013, 5(12): 100-109. https://doi.org/10.5539/jas.v5n12p100.

[24] Villa-Rodríguez, J.A., F.J. Molina-Corral, J.F. Ayala-Zavala, Olivas G.I & González-Aguilar, G.A. Effect of maturity stage on the content of fatty acids and antioxidant activity of 'Hass' avocado. Food Research International. 2011, 44(5): 1231-1237. https://doi.org/10.1016/j.foodres.2010.11.012.

[25] Abaide, E.R., G.L. Zabot, M.V. Tres, R.F. Martins, J.L. Fagundez, L.F. Nunes, S. Druzian, J.F. Soares, V. Dal Prá & Silva,J.R. Yield, composition, and antioxidant activity of avocado pulp oil extracted by pressurized fluids. Food and Bioproducts Processing. 2017, 102: 289-298. https://doi.org/10.1016/j.fbp.2017.01.008 .

[26] Rotta, E.M., D.R. de Morais, P.B.F. Biondo, V.J. dos Santos, M. Matsushita & Visentainer, J.V. Use of avocado peel (Persea americana) in tea formulation: a functional product containing phenolic compounds with antioxidant activity. Acta Scientiarum. Technology. 2016, 38(1): 23-29. https://doi.org/10.1016/j.fbp.2017.01.008.

[27] Nabavi, S.F., S.M. Nabavi, W.N. Setzer, S.A. Nabavi, S.A. Nabavi & Ebrahimzadeh, M.A. Antioxidant and antihemolytic activity of lipid-soluble bioactive substances in avocado fruits. Fruits. 2013, 68(3): 185-193. https://doi.org/10.1051/fruits/2013066 .

[28] Abd Elkader, A.M., S. Labib, T.F. Taha, F. Althobaiti, A. Aldhahrani, H.M. Salem, A. Saad & Ibrahim, F.M. Phytogenic compounds from avocado (Persea americana L.) extracts; antioxidant activity, amylase inhibitory activity, therapeutic potential of type 2 diabetes. Saudi journal of biological sciences. 2022, 29(3): 1428-1433. https://doi.org/10.1016/j.sjbs.2021.11.031.

[29] Corrales-García, J.E., M. del Rosario García-Mateos, E. Martínez-López, A.F. Barrientos-Priego, M.C. Ybarra-Moncada, E. Ibarra-Estrada, Méndez-Zúñiga S.M & D. Becerra-Morales, Anthocyanin and oil contents, fatty acids profiles and antioxidant activity of Mexican landrace avocado fruits. Plant Foods for Human Nutrition. 2019, 74: 210-215. https://doi.org/10.1007/s11130-019-00721-1.

[30] Terasawa, N., M. Sakakibara & Murata, M. Antioxidative activity of avocado epicarp hot water extract. Food Science and Technology Research. 2006, 12(1): 55-58. https://doi.org/10.3136/fstr.12.55.

[31] Tahsin, A., R. Arif Muhammed, E. Bayrakdarc & Uthirapathy, S. In-Vitro Antioxidant Activity of Avocado Fruit Oil in Erbil, Kurdistan Region. Eurasian Journal of Science and Engineering. 2023, 8(3): 298-307. https://doi.org/10.23918/eajse.v8i3p298.

[32] Rozan, M.A., Boriy E.G & Bayomy,HM. Chemical composition, bioactive compounds and antioxidant activity of six avocado cultivars Persea americana Mill.(Lauraceae) grown in Egypt. Emirates Journal of Food and Agriculture. 2021. https://doi.org/10.9755/ejfa.2021.v33.i10.2772.

[33] Nagaraj, M., V. Sandhya, G. Supriya, R. Manju, K. Pranitha, B. Shivaji, Lalitha V.L & Kiran,B. Antioxidant and antibacterial activity of avocado (Persea gratissima Gaertner.) seed extract. World Applied Sciences Journal. 2010, 9(6): 695-698.

[34] Elosaily, A.H., E.A. Mahrous, A.A. Salama, Salama A.M & Elzalabani, S.M. Composition, anti-inflammatory, and antioxidant activities of avocado oil obtained from Duke and Fuerte cultivars. Journal of the American Oil Chemists' Society. 2022, 99(2): 181-186. https://doi.org/10.1002/aocs.12565.

[35] Zavala-Guerrero, B., A. Hernandez-Garcia, R. Torres-Martinez, E. Melendez-Herrera, P. Rios-Chavez, A. Ochoa-Zarzosa, J.E. López-Meza, Saavedra-Molina A. & Salgado-Garciglia,R. Antioxidant and Anti-inflammatory Activities of Methanolic Fraction from Native Mexican Avocado Seed Oil. The FASEB Journal. 2020, 34(S1): 1-1. https://doi.org/10.1096/fasebj.2020.34.s1.07300.

[36] Hürkul, M.-M., S.-Y. Sarıaltın, Köroğlu A & Çoban, T. In vitro inhibitory potential of avocado fruits, Persea americana (Lauraceae) against oxidation, inflammation and key enzymes linked to skin diseases. Revista de Biología Tropical. 2021, 69(2): 472-481. http://dx.doi.org/10.15517/rbt.v69i2.41494.

[37] Sunday, C.U., H.O. Ndidiamaka, Ugochukwu D.D &. Njideka, I.A. Phytochemical Analysis and Antioxidant Activity of Avocado Pear Peel (Persea americana) Extract. Journal of Pharmaceutical Research International. 2022, 34(28A): 22-29. https://doi.org/10.9734/JPRI/2022/v34i28A36018.

[38] Ngungeni, Y., J. A. Aboyewa, K.L. Moabelo, N.R. Sibuyi, S. Meyer, M.O. Onani, Meyer M & Madiehe,A.M. Anticancer, Antioxidant, and Catalytic Activities of Green Synthesized Gold Nanoparticles Using Avocado Seed Aqueous Extract. ACS omega. 2023, 8(29): 26088-26101.

[39] Charles, A.C., Dadmohammadi Y & A. Abbaspourrad, A. Food and cosmetic applications of the avocado seed: a review. Food & Function. 2022, 13(13): 6894-6901. https://doi.org/10.1039/D1FO02438H.

[40] Pușcaș, A., A.E. Tanislav, R.A. Marc, V. Mureșan, A.E. Mureșan, Pall E & Cerbu, C. Cytotoxicity Evaluation and Antioxidant Activity of a Novel Drink Based on Roasted Avocado Seed Powder. Plants. 2022, 11(8): 1083. https://doi.org/10.3390/plants11081083.

[41] Aprilianto, E., A.V.H.S. Yuan, Pradita C.D & Hendra, P. Anti-inflammatory effects of avocado peels against inflammation induced by carrageenan in mice. Pharmaciana. 2019, 9(2): 219-226. https://doi.org/10.12928/pharmaciana.v9i2.13607.

[42] Dewi, A., Tianri S.V & Hendra, P. Anti-inflammatory and analgesic activities of avocado seed (persea americana mill.) aktivitas antiinflamasi dan analgesik biji alpukat (Persea americana mill.) caecilia desi kristanti, fransisca puspa jelita simanjuntak, ni kadek pramita. Jurnal Farmasi Sains dan Komunitas. 2017, 14(2): 104-111. http://dx.doi.org/10.24071/jpsc.142858.

[43] Dabas, D.,Ziegler G& Lambert, J. Anti-Inflammatory Properties of a Colored Avocado Seed Extract. Advantace Food Technology NutrIitional Sciences. 2019, 5: 8-12. https://doi.org/10.17140/AFTNSOJ-5-151.

[44] Kristanti, C.D., F.P.J. Simanjuntak, N.K.P.A. Dewi, S.V. Tianri S.V & Hendra, P. Anti-inflammatory and analgesic activities of avocado seed (Persea americana Mill.). Journal of Pharmaceutical Sciences and Community. 2017, 14(2): 104-111. https://doi.org/10.24071/jpsc.142858.

[45] Ovalle Marín, A., C. Parra Ruiz, F. Rivas Zambrano, J. Orellana, D. García Díaz& P. Jiménez Patiño, Characterization of Persea americana Mill. peels and leaves extracts and analysis of its potential in vitro anti-inflammatory properties. 2020.

[46] Oliveira, A.P., E.d.S. Franco, R. Rodrigues Barreto, D.P. Cordeiro, R.G. de Melo, C.M.F. de Aquino, P.L. de Medeiros, T.G. da Silva, Góes A.J & Maia, MB.Effect of semisolid formulation of Persea americana Mill (avocado) oil on wound healing in rats. Evidence-Based Complementary and Alternative Medicine. 2013, 2013. https://doi.org/10.1155/2013/472382.

[47] Goudarzi, R., A. Partoazar, F. Mumtaz, H. Yousefi-Manesh, Abdollahi, A. Dehpour A & Rashidian, A. Arthrocen, an avocado-soy unsaponifiable agent, improves acetic acid-induced colitis in rat by inhibition of NF-kB signaling pathway. Journal of Food Biochemistry. 2020, 44(7): e13244. https://doi.org/10.1111/jfbc.13244

[48] Hasti, S., N. Rahmawati, Utami R & Muharnis, R. Study on Antiinflammatory Effect of N-Hexane And Ethyl Acetate Extract Of Avocado Seed (Persea americana MILL.) on white mice (Mus musculus). Proceeding of "The International Conference on Herbal Medicine Industrialization as Complementary Therapy in Natural Disaster. 2020, 4(2): 42-47.

[49] Soumya, G., 1Akpomie, OO, 1Ehwarieme, DA, O., Ajise, JE, Kovo, GA. Antimicrobial Activity of Persea americana seed extract. Nigerian Journal of Microbiology. 2021.2(1): 45-49. https://doi.org/10.4314/bajopas.v2i1.58538.

[50] Guzmán-Rodríguez, J.J., R. López-Gómez, L.M. Suárez-Rodríguez, R. Salgado-Garciglia, L.C. Rodríguez-Zapata, A. Ochoa-Zarzosa S.M & . López-Meza, J.E. Antibacterial activity of defensin PaDef from avocado fruit (Persea americana var. drymifolia) expressed in endothelial cells against Escherichia coli and Staphylococcus aureus. BioMed research international. 2013. https://doi.org/10.1155/2013/986273.

[51] Amado, D.A.V., G.A.B. Helmann, A.M. Detoni, S.L.C.d. Carvalho, C.M.d. Aguiar, C.A. Martin, Tiuman T.S & Cottica, S.M. Antioxidant and antibacterial activity and preliminary toxicity analysis of four varieties of avocado (Persea americana Mill.). Brazilian Journal of Food Technology. 2019, 22. https://doi.org/10.1590/1981-6723.04418.

[52] Elosaily, A., E.A. Mahrous, Salama A & Elzalabani, S. Correlation between Genetic Variability, Chemical Composition and Antimicrobial Activity of Essential Oils Isolated from Avocado Cultivars Grown in Egypt. Egyptian Journal of Chemistry. 2021, 64(11): 6155-6159. https://doi.org/10.21608/EJCHEM.2021.71641.3574.

[53] Salinas-Salazar, C., C. Hernández-Brenes, D.G. Rodríguez-Sánchez, E.C. Castillo, Navarro-Silva J.M & Pacheco, A. Inhibitory activity of avocado seed fatty acid derivatives (acetogenins) against Listeria monocytogenes. Journal of Food Science. 2017, 82(1): 134-144. https://doi.org/10.1111/1750-3841.13553.

[54] Ilesanmi, T., O. Oladipo, Olaleye A & Osasona, O. Antimicrobial Activity of Essential Oil from Avocado (Persea americana) Seed and Pulp on Some Pathogenic Organisms. South Asian Journal of Research in Microbiology. 2022, 12(3): 61-68. https://doi.org/10.9734/SAJRM/2022/v12i330276.

[55] Raymond Chia, T.W. & Dykes, G.A. Antimicrobial activity of crude epicarp and seed extracts from mature avocado fruit (Persea americana) of three cultivars. Pharmaceutical Biology. 2010, 48(7): 753-756. https://doi.org/10.3109/13880200903273922

[56] Nwaoguikpe, Braide R.W & Ujowundu, C. Biochemical composition and antimicrobial activities of seed extracts of avocado (Persea americana). Journal of Microbiology and Antimicrobials. 2011, 3(7): 184-190.

[57] Pacheco, A., D.G. Rodríguez-Sánchez, R. Villarreal-Lara, J.M. Navarro-Silva, Senés-Guerrero C & Hernández-Brenes, C. Stability of the antimicrobial activity of acetogenins from avocado seed, under common food processing conditions, against Clostridium sporogenes vegetative cell growth and endospore germination. International journal of food science & technology. 2017, 52(11): 2311-2323. https://doi.org/10.1111/ijfs.13513

[58] Gomez-Flores, R., C. Arzate-Quintana, R. Quintanilla-Licea, P. Tamez-Guerra, R. Tamez-Guerra, Monreal-Cuevas E & Rodríguez-Padilla, EC. Antimicrobial activity of Persea americana Mill (Lauraceae)(Avocado) and Gymnosperma glutinosum (Spreng.) Less (Asteraceae) leaf extracts and active fractions against Mycobacterium tuberculosis. American-Eurasian Journal of Scientific Research. 2008, 3(2): 188-194.

[59] Leite, J.J.G., É.H.S. Brito, R.A. Cordeiro, R.S.N. Brilhante, J.J.C. Sidrim, L.M. Bertini, Morais S.M.D & Rocha, MFG. Chemical composition, toxicity and larvicidal and antifungal activities of Persea americana (avocado) seed extracts. Revista da Sociedade Brasileira de Medicina Tropical. 2009, 42: 110-113. https://doi.org/10.1590/S0037-86822009000200003.

[60] Jesus, D., J. Oliveira, F. Oliveira, K. Higa, J. Junqueira, A. Jorge, Back-Brito G & Oliveira, L. Persea americana glycolic extract: In vitro study of antimicrobial activity against candida albicans biofilm and cytotoxicity evaluation. The Scientific World Journal. 2015, 2015. https://doi.org/10.1155/2015/531972.

[61] Akalazu, J.N. & Uchegbu, R.I. Biochemical composition and antimicrobial activities of seed extracts of avocado (Persea americana). The FASEB Journal. 2020, 34(S1): 1-1.

[62] Egbuonu, A.C.C., I.C. Opara, Onyeabo C & Uchenna,N.O. Proximate, functional, antinutrient and antimicrobial properties of avocado pear (Persea americana) Seeds. Journal of Nutritional Health and Food Engineering. 2018, 8(2): 00260. https://doi.org/10.15406/jnhfe.2018.08.00260.

[63] Trujillo-Mayol, I., N. Casas-Forero, E. Pastene-Navarrete, Lima Silva F & Alarcón-Enos, J. Fractionation and hydrolyzation of avocado peel extract: Improvement of antibacterial activity. Antibiotics. 2020, 10(1): 23. https://doi.org/10.3390/antibiotics10010023 .

[64] Hernández-Martínez, M.A., L.M. Suárez-Rodríguez, J.E. López-Meza, A. Ochoa-Zarzosa, R. Salgado-Garciglia, Fernández-Pavia S.P & López-Gómez, R. Antifungal Activity of Avocado Seed Recombinant GASA/Snakin PaSn. Antibiotics. 2022, 11(11): 1558. https://doi.org/10.3390/antibiotics11111558.

[65] David, D., A. Alzate, B. Rojano, L. Copete-Pertuz, Jhony Gutierrez R & Zapata-Vahos,I. Extraction and characterization of phenolic compounds with antioxidant and antimicrobial activity from avocado seed (Persea americana mill). Revis Bionatura 2022; 7 (4): 51-60.

[66] Ezati, P., J.-W. Rhim, Molaei R & Rezaei, Z. Carbon quantum dots-based antifungal coating film for active packaging application of avocado. Food Packaging and Shelf Life. 2022, 33: 100878. https://doi.org/10.1016/j.fpsl.2022.100878.

[67] RajeshKumar, S. & Rinitha, G. Nanostructural characterization of antimicrobial and antioxidant copper nanoparticles synthesized using novel Persea americana seeds. OpenNano. 2018, 3: 18-27. https://doi.org/10.1016/j.onano.2018.03.001.

[68] Villarreal-Lara, R., D.G. Rodríguez-Sánchez, R.I. Díaz De La Garza, M.I. García-Cruz, A. Castillo, Pacheco A & Hernández-Brenes, C. Purified avocado seed acetogenins:

Antimicrobial spectrum and complete inhibition of Listeria monocytogenes in a refrigerated food matrix. CyTA-Journal of Food. 2019, 17(1): 228-239. https://doi.org/10.1080/19476337.2019.1575908.

[69] Ogunlade, A., U. Azunnaya, Afolabi O & Fakomiti, D. Antimicrobial activity and phytochemical screening of extract of avocado leaf (persea americana) against selected clinical isolates. Using Citrullus colocynthis, Ricinus communis and Parkia biglobosa Seeds. Journal of Science. 2010, 4(2): 12-16.

[70] Pe, N.N., H.H.S. San San Win, N.M. Wai N.M & Mandalay, M. Phytochemical Screening, Antimicrobial Activities and Functional Groups Determination of Isolate Organic Compound from the Barks of Avocado. Journal of Science. 2010, 4(3): 46-51.

[71] Fernández-Castañeda, L.A., H. Arias-Candamil, Zapata-Torres B & Ardila-Castañeda, M.P. Evaluation of the antimicrobial capacity of Hass avocado seed extract (Persea americana) for potential application in the meat industry. Dyna. 2018, 85(207): 346-350. https://doi.org/10.15446/dyna.v85n207.72980.

[72] Scarpassa C.,, L. Pretto, G.E. Otaguiri, S. Yamada-Ogatta, G. Nakazato, M. Perugini, Moreira I & Vilas-Bôas, G. Antibacterial activity of avocado extracts (Persea americana Mill.) against Streptococcus agalactiae. Phyton. 2016, 85: 218.

[73] Servillon, R.J.T., M.C.C. Dingal, M.C. Lusica, M.K.A. Yamson, Balonebro M.J.B & Alzate, F.B. Phytochemical Screening and in-vitro Antibacterial Evaluation of Persea americana (Avocado) Crude Peel Extract. Optima. 2013, 1(1): 1-1.

[74] Makopa, M., B. Mangiza, B. Banda, W. Mozirandi, Mombeshora M & Mukanganyama, S. Antibacterial, antifungal, and antidiabetic effects of leaf extracts from Persea americana Mill.(Lauraceae). Biochemistry Research International. 2020, 2020: 1-10. https://doi.org/10.1155/2020/8884300.

[75] Bamidele, F., F. Ogundipe, S. Osaide, Chucku G & Olonode, E. Antimicrobial activity and preliminary phytochemical screening of oil extracted from food waste generated from Persea americana. Nigerian Journal of Science and Environment. 2021, 19(2): 17-27.

[76] Kautsar, D.B., M.F. Rois, N. Faizah, W. Widiyastuti, Nurtono T & Setyawan, H. Antioxidant and Antimicrobial Agents from Avocado (Persea Americana) Seed Extract Encapsulated in Gum Arabic through Spray Drying Method. Periodica Polytechnica Chemical Engineering. 2023, 67(1): 161-171. https://doi.org/10.3311/PPch.20698.

[77] Teresa, R.-C.M., V.-G. Rosaura, Elda C.M & Ernesto,G.P. The avocado defense compound phenol-2, 4-bis (1, 1-dimethylethyl) is induced by arachidonic acid and acts via the inhibition of hydrogen peroxide production by pathogens. Physiological and molecular plant pathology. 2014, 87: 32-41. https://doi.org/10.1016/j.pmpp.2014.05.003

[78] Abdulrahman, M.D. & Hamad, S.W. Traditional methods for treatment and management of measles in Northern Nigeria: Medicinal plants and their molecular docking. Ethnobotany Research and Applications. 2022, 23. http://dx.doi.org/10.32859/era.23.33.1-18.

[79] Abba, A. & Dogara, A.M. Ethnomedicinal survey of plants used for management of inflammatory diseases in Ringim local government, Jigawa state, Nigeria. Ethnobotany Research and Applications. 2021, 22: 1-27.

[80] Louis, M.L.M., V.P. Rani, P. Krishnan, A.D. Reegan, K. Balakrishna, S. Ignacimuthu, S.M. Packiam, Maheswaran R & Shirota, O. Mosquito larvicidal activity of compounds from unripe fruit peel of avocado (Persea americana Mill.). Applied Biochemistry and Biotechnology. 2023, 195(4): 2636-2647. https://doi.org/10.1007/s12010-022-03831-w.

[81] Al-Otaibi, T., M.A. Hawsah, G. Alojayri, M.M. Mares, H.M. Aljawdah, S.N. Maodaa, E.M. Al-Shaebi, M.A. Dkhil, Thagfan F.A & Al-Quraishy, S. In vivo anticoccidial, antioxidant, and anti-inflammatory activities of avocado fruit, Persea americana (Lauraceae), against

Eimeria papillata infection. Parasitology International. 2023, 95: 102741. https://doi.org/10.1016/j.parint.2023.102741

[82] Hassan, M., S. Abdel Moneim, Mahmoud E.A.M & Mohamed,D.A. Antioxidant, anti-Cancer and anti-Arthritic activities of Acetogenin rich extract of Avocado pulp. Egyptian Journal of Chemistry. 2022, 65(2): 539-550. https://doi.org/10.21608/ejchem.2021.90308.4309.

[83] Umoh, I., O. Samuel, Kureh T & Davies, K. Antidiabetic and hypolipidaemic potentials of ethanol fruit pulp extract of Persea americana (avocado pear) in rats. Journal of African Association of Physiological Sciences. 2019, 7(1): 59-63.

[84] Ojo, O.A., J.C. Amanze, A.I. Oni, S. Grant, M. Iyobhebhe, T.C. Elebiyo, D. Rotimi, N.T. Asogwa, Oyinloye B.E & Ajiboye, B.O. Antidiabetic activity of avocado seeds (Persea americana Mill.) in diabetic rats via activation of PI3K/AKT signaling pathway. Scientific reports. 2022, 12(1): 2919. https://doi.org/10.1038/s41598-022-07015-8.

[85] Kouamé, N.G.M., C. Koffi, K.S. N'Zoué, N. Yao, B. Doukouré B & Kamagaté, M. Comparative antidiabetic activity of aqueous, ethanol, and methanol leaf extracts of Persea americana and their effectiveness in type 2 diabetic rats. Evidence-Based Complementary and Alternative Medicine. 2019, 2019.

[86] Lima, C., C. Vasconcelos, J. Costa-Silva, C. Maranhão, J. Costa, T. Batista, E. Carneiro, L. Soares, Ferreira F & Wanderley, A. Anti-diabetic activity of extract from Persea americana Mill. leaf via the activation of protein kinase B (PKB/Akt) in streptozotocin-induced diabetic rats. Journal of Ethnopharmacology. 2012, 141(1): 517-525.

[87] Alhassan, A., M. Sule, M. Atiku, A. Wudil, Abubakar H & Mohammed, S. Effects of aqueous avocado pear (Persea americana) seed extract on alloxan induced diabetes rats. Greener Journal of Medical Sciences. 2012, 2(1): 005-011. https://doi.org/10.15580/GJMS.2012.1.GJMS1202

[88] Razola Díaz, M.d.C., S.d. Montijo Prieto, M.J. Aznar Ramos, M. Jiménez Varela, A. Ruiz-Bravo López, Verardo V & Gómez Caravaca, A.M. Article Effect of Lactic Acid Bacteria Fermentation on the Polar Compounds Content with Antioxidant and Antidiabetic Activity of Avocado Seed Extracts. 2023.

[89] Antia, B., Okokon J & Okon, P. Hypoglycemic activity of aqueous leaf extract of Persea americana Mill. Indian journal of pharmacology. 2005, 37(5): 325.

[90] Ajani, A. & Olanrewaju,B.O. Avocado pear fruits and leaves aqueous extracts inhibit α-amylase, α-glucosidase and snp induced lipid peroxidation–an insight into mechanisms involve in management of type 2 diabetes. Int J Appl Nat Sci. 2014, 3: 21-34.

[91] Khedr, S.A. & El-Badry,S. Possible Effects of mango, avocado seeds and their mixture in Alloxan-Induced Diabetic Rats. Journal of Home. 2020, 30(4): 1-12.

[92] Rahman, N., I.M. Tangkas, S.M. Sabang, Bohari B & Abdullah, R. The Avocado (Persea americana Mill.) Leaf Extract on Streptozotocin-induced Pancreatic Cell Regeneration of White Rats (Rattus norvegicus). Open Access Macedonian Journal of Medical Sciences. 2021, 9(A): 849-853.

[93] Ezejiofor, A.N., Okorie A & Orisakwe, O.E. Hypoglycaemic and tissue-protective effects of the aqueous extract of Persea americana seeds on alloxan-induced albino rats. The Malaysian journal of medical sciences: MJMS. 2013, 20(5): 31-51.

[94] Kumala, S, Utami S.H & Sari, W.K. The effect of avocado (Persea americana Mill.) leaves extract towards the mouse's blood glucose decrease with the glucose tolerance method. International journal of pharmaceutical sciences and research. 2013, 4(2): 61-69.

[95] Nardi, L., I.N. Lister, Girsang E & Fachrial, E. Hypoglycemic Effect of Avocado Seed Extract (Persean americana Mill.) from Analysis of Oral Glucose Tolerance Test On Rattus

norvegicus L. American Scientific Research Journal for Engineering, Technology, and Sciences. 2020, 65: 49-56.

[96] Ogundeko, T.O., N.P. Okoye, Ogbole E.A & Dauda, D. Effect of acute and chronic administration of hot water extract of P. Americana on some metabolic parameters in diabetic rats. World. 2022, 3(02): 001-009.

[97] Labaran, I., M.D. Abdulrahman, S.W. Hamad, Lema A.B.A & Jakada, B.H. Traditional medicinal plants used for the treatment of cancer in Mubi, Adamawa State, Nigeria. Al-Qadisiyah Journal of Pure Science. 2021, 26(4): 258-268. https://doi.org/10.29350/qjps.2021.26.4.1423.

[98] Ahmed, O.M., H.I. Fahim, Mohamed E.E & Abdel-Moneim, A. Protective effects of Persea americana fruit and seed extracts against chemically induced liver cancer in rats by enhancing their antioxidant, anti-inflammatory, and apoptotic activities. Environmental Science and Pollution Research. 2022, 29(29): 43858-43873. https://doi.org/10.1007/s11356-022-18902-y.

[99] Widiyastuti, Y., R. Pratiwi, Riyanto S & Wahyuono, S. Cytotoxic activity and apoptosis induction of avocado Persea americana Mill. seed extract on MCF-7 cancer cell line. Indonesian Journal of Biotechnology. 2018, 23(2): 61-67.

[100] Abubakar, A.N.F., Achmadi S.S & Suparto, H.I. Triterpenoid of avocado (Persea americana) seed and its cytotoxic activity toward breast MCF-7 and liver HepG2 cancer cells. Asian Pacific Journal of Tropical Biomedicine. 2017, 7(5): 397-400.

[101] Zhao, Z., N. Hamid, L. Qian, N. Gutierrez-Maddox, R. Kam, K. Kantono, K. Wang, Lu J & Le, T.T. The effects of roasting on antioxidant and anticancer activities of fermented Hass avocado seeds. Frontiers in Food Science and Technology. 2022, 2: 986868. https://doi.org/10.3389/frfst.2022.986868.

[102] Larijani, L.V., M. Ghasemi, S. AbedianKenari& F. Naghshvar, Evaluating the effect of four extracts of avocado fruit on esophageal squamous carcinoma and colon adenocarcinoma cell lines in comparison with peripheral blood mononuclear cells. Acta Medica Iranica. 2014: 201-205.

[103] Guzmán-Rodríguez, J.J., R. López-Gómez, R. Salgado-Garciglia, A. Ochoa-Zarzosa& J.E. López-Meza, The defensin from avocado (Persea americana var. drymifolia) PaDef induces apoptosis in the human breast cancer cell line MCF-7. Biomedicine & Pharmacotherapy. 2016, 82: 620-627.

[104] Lu, Q.-Y., J.R. Arteaga, Q. Zhang, S. Huerta, Go V.L.W & Heber, D. Inhibition of prostate cancer cell growth by an avocado extract: role of lipid-soluble bioactive substances. The Journal of nutritional biochemistry. 2005, 16(1): 23-30.

[105] Paul, R., Kulkarni R.P & Ganesh, N. Avocado fruit (Persea americana Mill) exhibits chemo-protective potentiality against cyclophosphamide induced genotoxicity in human lymphocyte culture. Journal of Experimental Therapeutics and Oncology. 2011, 9(3): 221-30.

[106] Ant, A., A. Avcı, M. Genç, E. İnal, Tunçel U & Z. Şencan, Z. Avocado leaf extract activates Adenosine Deaminase (ADA) in Larynx cancer tissues Avokado yaprağı ekstresinin Larinks kanseri dokularında Adenozin Deaminaz (ADA) üzerine aktive edici etkisi.. 2018, 51(2): 199-204 | https://doi.org/10.5505/aot.2018.88319

[107] Bonilla-Porras, A.R., A. Salazar-Ospina, M. Jimenez-Del-Rio, Pereañez-Jimenez A & Velez-Pardo, C. Pro-apoptotic effect of Persea americana var. Hass (avocado) on Jurkat lymphoblastic leukemia cells. Pharmaceutical Biology. 2014, 52(4): 458-465.

[108] Padilla-Arellanes, S., R. Salgado-Garciglia, M. Báez-Magaña, Ochoa-Zarzosa A & López-Meza, J.E. Cytotoxicity of a lipid-rich extract from native mexican avocado seed (Persea

americana var. drymifolia) on canine osteosarcoma D-17 cells and synergistic activity with cytostatic drugs. Molecules. 2021, 26(14): 4178.

[109] Athaydes, B.R., G.M. Alves, A.L.E.M. de Assis, J.V.D. Gomes, R.P. Rodrigues, B.P. Campagnaro, B.V. Nogueira, D. Silveira, Kuster R.M. & Pereira, T.M.C. Avocado seeds (Persea americana Mill.) prevents indomethacin-induced gastric ulcer in mice. Food Research International. 2019, 119: 751-760.

[110] Ojewole, J.A. & Amabeoku, G.J. Anticonvulsant effect of Persea americana Mill (Lauraceae)(Avocado) leaf aqueous extract in mice. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2006, 20(8): 696-700.

[111] Padilla-Camberos, E., M. Martínez-Velázquez, Flores-Fernández J.M & Villanueva-Rodríguez, S. Acute toxicity and genotoxic activity of avocado seed extract (Persea americana Mill., cv Hass). The Scientific World Journal. 2013. https://doi.org/10.1155/2013/245828.

[112] Dogara, A.M., S.W. Hamad, H.A. Hama, S.W. Bradosty, S. Kayfi, Al-Rawi S.S & Lema, A.A. Biological evaluation of Garcinia kola Heckel. Advances in Pharmacological and Pharmaceutical Sciences. 2022. https://doi.org/10.1155/2022/3837965

[113] Aadil, K.R., A. Barapatre, S. Sahu, Jha H & Tiwary, B.N. Free radical scavenging activity and reducing power of Acacia nilotica wood lignin. International Journal of Biological Macromolecules. 2014, 67: 220-227. https://doi.org/10.1016/j.ijbiomac.2014.03.040.