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An Update on *Prunus Armeniaca* Phytochemical Composition and Biological Activities

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Abstract

The irrational use of drugs has led to antimicrobial resistance and tolerance to most commercial drugs posing a global threat to future management of diseases. Hence there is need to search for new drugs from medicinal edible plants to be incorporated in the nutraceutical management of diseases. The challenges facing the utilization of medicinal edible fruits are the lack of sufficient studies to ascertain their quality, safety and efficacy. *Prunus armeniaca* (Rosaceae) also known as Apricot is a delicious and most commercial traded fruit globally. *Prunus armeniaca* can either be consumed as a fresh fruit, dried fruit, processed juice, jam or nectar. This review article purposes to give an up-to-date understanding of the *Prunus armeniaca* medicinal edible fruit biological activities and phytochemical composition that have been outlined in grey and published literature. Literature has been reviewed using search engines such as Google Scholar, HINARI, Science Direct, PubChem, Sciverse, EBSCO and Scopus. Apricot provides a rich source of phytochemicals including but not limited to polyphenols, alkaloids, flavonoid glycosides, saponins, carotenoids, cyanogenic glucosides, fatty acids, sterol derivatives, volatile components, monosaccharides and polysaccharides. These phytochemicals have shown efficacious and safe biological activity. Biological activities such as antimicrobial, inhibitory activity against several enzymes, cardioprotective, anti-inflammatory, antinociceptive, antimutagenic as well as antioxidant activity have been demonstrated. *Prunus armeniaca* has been utilized in oriental medicine to treat diseases such as leprosy, asthma, leukoderma, bronchitis, constipation, emphysema and nausea. Its safety and toxicity have not been well documented hence the need for evaluation. More studies are needed to elucidated more phytochemicals and biological activities, efficacy, safety and toxicity measures. *Prunus armeniaca* will provide a source of health promoting health constituent in nutraceutical and new remedy for the emerging resistant human pathogens in the fight against antimicrobial resistance and drug tolerance.

Keywords: Prunus Armeniaca; Apricot; Rosaceae; Biological Activity; Phytochemistry

Introduction

Antimicrobial resistance is a growing challenge of global prime concern. It has resulted to loss of global economy and there is need to stall the current trend of antimicrobial resistance development. The irrational use of antibiotics both in humans and animals is responsible for the antimicrobial resistance and hence the need for justified utilization of antibiotics for non-therapeutic purposes like growth promotion and therapeutic indications. There is need to search for substitutes to antibiotics with different mode of action in prevention of infectious diseases. These alternative remedies will minimize the dependency on antibiotics and provide a solution to the challenges in commercialization

and future scope of alternative remedies [1].

Infectious diseases bear a serious impact on patient wellbeing and cost of healthcare. There is lack of well-established treatment protocols for use of antibiotics in the prevention of urinary tract infection recurrences. Antibiotic therapy damages the microbiota and rises the risk of spreading multidrug resistance pathogens. The employment of phytotherapy to relieve the symptoms and reduce the recurrence of symptoms provides an appealing substitute. Nutraceuticals or phytotherapy provides a new approach to the management of patients with infectious diseases [2].

Prunus armeniaca fruit is common in temperate and is the 3rd most economically traded fruit globally after plum and peach. The *Prunus armeniaca* fruit or apricot originated from the "golden fruit" from its nutritional properties and medicinal values. It belongs to family *Rosaceae*. *Prunus armeniaca* consists high levels of phytochemicals namely flavonoids, carotenoids, antioxidants and phenolics. It has a spectacular yellow to orange colours with reddish random overlay, a heavy fragrance and a marked flavour. *Prunus armeniaca* fruit can be consumed fresh, dried, or processed into jam or juice [3].

Figure 1: A picture of *Prunus armeniaca* fruits courtesy of https://www.alamy.com/stock-photo/prunus-armeniaca.html

These phytochemicals have shown efficacious and safe biological activity. Biological activities such as antimicrobial, inhibitory activity against several enzymes, cardioprotective, anti-inflammatory, antinociceptive, antimutagenic as well as antioxidant activity have been demonstrated. *Prunus armeniaca* has been utilized in oriental medicine to treat diseases such as leprosy, asthma, leukoderma, bronchitis, constipation, emphysema and nausea [4-6]. However, the data on scientific studies to reveal the efficacy, safety and chemical composition of the *Prunus armeniaca* is not available.

This review aims to ascertain if *Prunus armeniaca* is a valuable lead compound for nutraceutical development and phytotherapy of investigational drug and if the phytochemical constituents of *Prunus armeniaca* are potential antimicrobial agents to overcome antimicrobial resistance and drug tolerance. Additionally, this review provides comprehensive overview of published data regarding *Prunus armeniaca*: phytochemistry composition and biological activity of *Prunus armeniaca.* Therefore, the current review will provide empirical data that will be analyzed to rationalize the use of the phytochemicals from the *Prunus armeniaca fruit* to treat bacterial infections caused by human resistant pathogens.

Methodology

This review has been developed with the aid of peer reviewed articles, articles, theses, Science Direct, Google Scholar, validated internet sources and books. The search phrases included: *Prunus armeniaca*; Apricot; Rosaceae; Biological activity; Phytochemistry of *Prunus armeniaca*. The articles published from years 2007 to 2022 were considered in the review. The older literatures were valuable in the search for biological activities of *Prunus armeniaca*. Relevant articles were accessed using inclusion and exclusion criteria.

Phytochemical Composition

Prunus armeniaca is rich in fatty acids, mono- and polysaccharides, cyanogenic glucosides, sterol derivatives, polyphenols, carotenoids and volatile components

contributing to its appealing smell [4,7]. Fibres, vitamins, lipids, sterols, essential oils, fatty acids, aldehydes, terpene alcohols, esters, sugars, amygdalin, quercetin-3-glucosides, neochlorogenic acid, kaempferol-3-rutinoside, rutin, *p*-coumaric acids, cyanidin-3-glucosides, epicatechin, ferulic acid, ethanol, epigallocatechin, catechin, alcohols, mineral acids such as zinc, phosphorous, magnesium, selenium, iron and calcium are present in *Prunus armeniaca* [8]. *Prunus armeniaca* has shown high values of monosaccharides including D-galactose, mannose, rhamnose, xylose and L-arabinose. Uronic acid, fat and proteins have also been isolated. Glycoside bonds, hydroxyl, methyl and carboxyl groups have been demonstrated using Fourier- transform infrared spectroscopy [5].

Cultivation activities, environmental conditions for ripening stages and genotype mainly determine the colour, taste and nutritional constituents of *Prunus armeniaca. The high levels of phenolics in Prunus armeniaca are gallic, chlorogenic, caffeic, ferulic, 4-aminobenzoic, salicylic, p-coumaric acid and procatechin. Major Flavonols in apricot are vanillin, glycoside rutin, resveratrol and quercetin. The Prunus armeniaca fruit is rich in carotenoids such as lutein, phytofluene, lycopene,* β-carotene, β-cryptoxanthin and phytoene. Organic acids and sugars are vital metabolites of *Prunus armeniaca provide fragrance and nutrition. The most abundant sugar is sucrose, followed by fructose, glucose and sorbitol. Fragrance, sweetness and consumer satisfaction is contributed by fructose and sucrose. Malic acid and citric acid are in high concentrations while ascorbic acid, succinic and* are in low concentrations [3].

Flavonoid glycosides have been isolated and elucidated by spectral studies from the *Prunus armeniaca* are 3,4′,5,7-tetrahydroxy-3′,5′-di-methoxy flavone 3-O- [α-L-rhamnopyranosyl (1‴→6″)]-β-D-galactopyranoside and 4′,5,7-trihydroxy flavone-7-O- [β-D-mannopyranosyl (1‴→2″)]-β-D-allopyranoside [9]. Pentadecanoic acid, Cyclodecasiloxane, 14-methyl-, methyl ester, Dibutyl phthalate eicosamethyl-, 14-methyl-, methyl ester, Dibutyl phthalate, 1-Monolinoleoylglycerol trimethylsilyl ether, 9-Octadecenamide, have been found in *Prunus armeniaca* [10]. Important phytochemicals like Palmitic acid, methyl ester, hexadecenoic acid, Cyclopentadecanone, 9-octadecenoic acid and heptadecanoic acid have been identified in *Prunus armeniaca* by chemical analysis [11].

Alkaloids, saponins, eugenol, vitamin E, sorbitol, fatty acids and phytosterol have been identified in phytochemical results. *Prunus armeniaca* has good energy sources, protein, dietary fiber and minerals such as potassium, copper, magnesium, iron, zinc and calcium, from nutritional results [12].

Phytochemical Constituents	References
Fatty acids	[4,7]
Mono- and polysaccharides	[4,7]
Cyanogenic glucosides	[4,7]
Sterol derivatives	[4,7]
Polyphenols	[4,7]
Carotenoids	[4,7]
Volatile components	[4,7]
Fibres	[8]
Vitamins, lipids, sterols	[8]
Essential oils, fatty acids	[8]
Aldehydes, terpene alcohols, esters	[8]
Sugars, amygdalin, quercetin-3-glucosides	[8]
Neochlorogenic acid,	[8]
Kaempferol-3-rutinoside, rutin	[8]
p-coumaric acids, cyanidin-3-glucosides	[8]
Epicatechin, ferulic acid, ethanol	[8]
Catechin, epigallocatechin, alcohols	[8]
Mineral acids	[8]
D-galactose, mannose, rhamnose	[5]
Xylose, L-arabinose	[5]
Uronic acid, fat, proteins	[5]
Phenolics,	[3]
Gallic, chlorogenic, caffeic	[3]
Ferulic, 4-aminobenzoic, salicylic	[3]
p-coumaric acid, procatechin	[3]
Vanillin, glycoside rutin,	[3]
Resveratrol, quercetin	[3]
Carotenoids	[3]
Lutein, phytofluene, lycopene	[3]
β-carotene, β-cryptoxanthin, phytoene	[3]
Organic acids, sugars	[3]
Sucrose, fructose, glucose, sorbitol	[3]
Malic acid, citric acid	[3]
Flavonoid glycosides	[11]
Palmitic acid, methyl ester	[11]
Hexadecenoic acid, Cyclopentadecanone	[11]
9-octadecenoic acid, heptadecanoic acid	[11]
Alkaloids, saponins, eugenol	[12]
Vitamin E, sorbitol	[12]
Fatty acids, phytosterol	[12]
Protein, dietary fiber, minerals	[12]

Table 1: Phytochemical Composition of *Prunus armeniaca*.

Biological Activities

Biological activities such as antimicrobial, inhibitory activity against several enzymes, cardioprotective, anti-inflammatory, antinociceptive, antimutagenic as well as antioxidant activity have been demonstrated. *Prunus armeniaca* has high antioxidant activity in both *in vitro* and *in vivo* test systems [4,5].

Cyanogenic glycosides are found in the apricot seeds have a bitter taste and are responsible for the intoxication of the thyroid and nervous system. Polyphenols are micronutrients abundant in human diets which have a role in prophylaxis of emerging degenerative diseases like cardiovascular diseases, immune-stimulating activity and cancer. Anticancer activity has been shown in pharmacological studies which can be validated by clinical trials [13,14]. Amygdalin is a cyanogenic glycoside present in *Prunus armeniaca* contributes to antimicrobial activity, anti-inflammatory properties, regenerative properties, skin diseases, respiratory disorders and treatment of colorectal cancer [7].

Flavonoid glycosides of extracts of *Prunus armeniaca fruits* have shown antibacterial activity against both Gram positive and Gram-negative bacteria [9,10,12]. *Prunus armeniaca* is employed in traditional medicine in treatment of skin infections and parasitic diseases. It has shown significant activity against *Staphylococcus aureus*, *Bacillus subtilis, Proteus vulgaris, Klebsiella pneumonia, Escherichia coli* and *Candida albicans* [15,16].

Organic acid in *Prunus armeniaca* like malic acid and citric acid plays a role in maintaining acid-base balance in ilium and enhancing iron bioavailability in the body after oral administration [17,18]. Carotenoids have antioxidant properties, immune enhancing activity, minimizing the oxidative stress, some types of cancers, prevention of macular degeneration and reduced risk of cardiovascular diseases [3].

Prunus armeniaca is rich in vitamin c and tocopherol essential for health promotion. It has antioxidant, control of lipid and glucose/insulin metabolism, anti-inflammatory and immune-stimulating [19]. Hydroxycinnamic acids and polyphenols obtained from the leaves of *Prunus armeniaca* have anticholinesterase (Butylcholinesterase and acetylcholinesterase), anti-obesity it acts by inhibiting pancreatic lipase, antidiabetic (α-glucosidase and α-amylase), COX-1 and COX-2 inhibition [20]. *Prunus armeniaca* seeds have been utilized in oriental medicine to treat dandruff, acne vulgaris and skin infections like furuncles. Essential oils extracted from the seeds exhibit antimicrobial properties against gram-positive bacteria, gram-negative bacteria and yeasts [21]. The leave extracts of this high medicinal value plant pose antileishmanial activity specifically for amastigotes and promastigotes of *Leishmania tropica* [22].

Silver and gold nanoparticles biosynthesized gum extracts of *Prunus armeniaca showed mild to moderate antibacterial inhibition against Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. *Prunus armeniaca* extracts of silver and gold nanoparticles have significant analgesics and anti-inflammatory activities. *Prunus armeniaca* has exhibited antifungal, nephroprotective, hepatoprotective, antiradical capacities, gastro-protective, anti-mutagenic, cardio-protective, anti-carcinogenic, testicular protective, trypsin and tyrosinase inhibitory activities. It has been utilized in oriental medicine to treat diseases such as eye inflammation, leprosy, infertility, asthma, leukoderma, bronchitis, constipation, wheeze, emphysema, haemorrhage, nausea, dandruff and acne vulgaris [6,11,23].

Cough expectoration, antitussive properties, analgesic, antifungal, tinnitus, anticholinesterase, ear inflammation and fever. It has also been employed in the management of COVID-19 to improve clinical cure rate, improve the state of the lungs, cough reduction and symptom score of coughs [18].

Biological Activities	References
Antimicrobial, inhibitory activity against several enzymes, cardioprotective, anti-inflammatory, antinociceptive, antimutagenic, antioxidant activity.	[4,5]
Prophylaxis of emerging degenerative diseases like cardiovascular diseases, immune-stimulating activity and cancer	[13,14]
Anticancer activity	[13,14]
Antimicrobial activity, anti-inflammatory properties, regenerative properties, skin diseases, respiratory disorders and treatment of colorectal cancer	[7]
Antibacterial activity against both Gram positive and Gram-negative bacteria	[9,10,12]
Treatment of skin infections and parasitic diseases	[15,16]

Significant activity against Staphylococcus aureus, Bacillus subtilis, Proteus vulgaris, Klebsiella pneumonia, Escherichia coli and Candida albicans	[15,16]
Maintaining acid-base balance in ilium and enhancing iron bioavailability in the body	[17,18]
Antioxidant properties, immune enhancing activity, minimizing the oxidative stress, some types of cancers, prevention of macular degeneration and reduced risk of cardiovascular diseases	[3]
Antioxidant, control of lipid and glucose/insulin metabolism, anti-inflammatory and immune-stimulating	[19]
Anticholinesterase (Butylcholinesterase and acetylcholinesterase), Anti-obesity, antidiabetic (α-glucosidase and α-amylase), COX-1 and COX-2 inhibition	[20]
Treat dandruff, acne vulgaris and skin infections like furuncles	[21]
Antileishmanial activity specifically for amastigotes and promastigotes of Leishmania tropica	[22]
Antibacterial inhibition against Staphylococcus aureus, Escherichia coli and Pseudomonas aeruginosa, analgesics, anti-inflammatory activities, antifungal, nephroprotective, hepatoprotective, antiradical capacities, gastro-protective, anti-mutagenic, cardio-protective, anti-carcinogenic, testicular protective, trypsin and tyrosinase inhibitory activities	[6,11,23]
Treat diseases such as eye inflammation, leprosy, infertility, asthma, leukoderma, bronchitis, constipation, wheeze, emphysema, haemorrhage, nausea, dandruff and acne vulgaris.	[6,11,23]
Cough expectoration, antitussive properties, analgesic, antifungal, tinnitus, anticholinesterase, ear inflammation and fever	[18]
Management of COVID-19 to improve clinical cure rate, improve the state of the lungs, cough reduction and symptom score of coughs	[18]

Table 2: Biological Activities of *Prunus armeniaca*.

Conclusion

This review has portrayed that *Prunus armeniaca* has substantial biological activities being utilized extensively in the oriental medicine for the management of a number of ailments which includes infectious diseases. *Prunus armeniaca* has shown antibacterial, anti-carcinogenic, antiparasitic, antifungal, anti-inflammatory properties, analgesic, anticholinesterase, antioxidant, cardioprotective and cough remedy. *Prunus armeniaca* phytochemical composition are convincing modulators of antimicrobial resistant pathogens and drug tolerance. Cyanogenic glycosides antimicrobial properties are due to enzymes inhibition in respiratory chain and attaching to enzymes containing heavy metals. The hydrogen cyanide released from the breakdown of cyanogenic glycosides inhibit the growth of bacteria by interfering with the electron transport chain responsible for bacterial respiration. Amygdalin is a cyanogenic glycoside found in *Prunus armeniaca* which exhibits antibacterial activity by its decomposition by bacterial β-glucosidase to release benzaldehyde and hydrogen cyanide causing bacterial growth inhibition. Phenolic constituents of *Prunus armeniaca* exhibit manifest antimicrobial properties by the disruption of cell wall and cell membrane. Flavonoids act y DNA gyrase inhibition and interfering with bacterial energy metabolism. Saponins act by penetrating the microorganism cells due to the lipophilic structure results into decreased surface tension increasing permeability or leakage of intracellular cell contents and inhibition of microbial protein synthesis. Alkaloids act by disrupting the microbial efflux pump functions. Terpenoids disrupt the cell membrane fluidity and permeability. Organic acids maintain the acid-base balance in the ilium. Carotenoids exhibit antimicrobial activity by suppression of microbial growth via causing cytoplasmic content leakage, interfering with periplasmic membrane permeability, inhibition of protein synthesis, generation of reactive oxygen species and arresting nucleic acid functions. Aldehydes act by irreversibly disrupting bacterial cell wall and cytoplasmic membrane leading bacterial cell decay and death. Alcohols act via coagulating proteins, denaturing the bacterial proteins and disrupting bacterial cell wall killing the bacteria and viruses. Esters contribute to the antibacterial activity by disrupting the bacterial cell wall and cell membrane.

Catechins act by lateral expansion/ membrane disruption hypothesis causing the lipid bilayer to intercalate creating spaces between lipids resulting in membrane permeability. They also act by reacting with dissolved oxygen producing hydrogen peroxide and hydroxyl radicals leading to protein and DNA damage inside the microbial cells. Neochlorogenic acid act by inhibiting the synthesis of bacterial cell membrane causing the loss of cell components and bacterial inactivation. P-coumaric acid acts by damaging cell membrane and attaching to bacterial genomic DNA causing inhibition of cellular functions and eventually

leading to cell death. Kaempferol exhibit bacteriostatic action by disrupting the bacterial energy metabolism, decreasing pathogenicity and resulting in damage of cellular integrity, cell content leakage and subsequent cell death. Additional studies need to be performed on *Prunus armeniaca* for identification of additional phytochemicals, structural elucidation and toxicity studies. Massive analysis is required to establish the efficacy and safety of *Prunus armeniaca* in oriental medicine and nutraceutical application. This review has established inadequate studies on phytochemicals and biological activities of *Prunus armeniaca* hence the necessity for further studies since *Prunus armeniaca* could contribute to fighting antimicrobial resistance when utilized accurately.

Data Availability

The data that has been used to hold up the findings of this study have been incorporated in the article.

Conflict of Interest

The author declares that there are no vested interests.

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