International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

Almond (*Purunus amygdalus* L.): A review on health benefits, nutritional value and therapeutic applications

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Abstract

Almond is a product of popular medicinal plant *Purunus amygdalus* L. which has been used to cure and prevent ailments from millennia. Almond trees are native to Asian countries. Almond is a valuable health benefiting food, as it is rich in antioxidants. It contains flavonoids, fatty acids, vitamins, proteins, and essential minerals. Cholesterol lowering effects of almonds are due to the presence of phytosterols. Almond has been used traditionally for curing wounds, anaemia, insomnia, headache, sore throat, brain infections, kidney disorders, urinary infections, uteralgia, pityriasis, hysteria. Major pharmacological properties of almond include hepatoprotective, anti-depressant, antioxidant, memory enhancing, and anti-aging effects. Present review describes phytochemistry, health benefits and medicinal properties of almond.

Keywords: Almond, postharvest, spiraeoideae, quercitin

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1. Botany

1.1. Introduction

Almond is a product of *Prunus amygdalus* L. which belongs to Rosaceae (rose family). Traditionally, almonds were placed in Prunoideae (sub-family), but most of the time, they are kept in their own family (Amygdalaceae or Prunaceae). Recently, it has become obvious that almonds evolved from Spiraeoideae family [1]. Three nuts producing varieties of almonds are available, out of which some are edible and some are non-edible. One variety of almonds produces edible sweet nuts, one produces non-edible bitter and poisonous nuts, while third variety is a blend of both sweet and bitter almonds. Commercially, two major kinds of almonds are cultivated, which can be classified as bitter almonds (*Prunus amygdalus* amara) and sweet almonds (*Prunus amygdalus* dulcis). Bitter and sweet almond producing plants can be identified on the basis of their flower color. Bitter almonds produce flowers of pinkish color, while flowers of sweet almonds are white [2]. Almond skin should be detached before use because it may cause allergy. Almond is known by different vernacular names in different regions of the world. It is known as sweet almond (English), badamshireen (Persian), lauzulhulu (Arabic), almendro (Spanish), amande (French), badanmu (Chinese), amendoeira (Portuguese), amygdalia (Greek), mandebaum (German), badamamu (Telgu), bilatibadam (Malayalam/Bengali) and badam (Hindi/Urdu).

1.2. History

Almond is native to western and central Asian countries. China has been cultivating it since 10th century B.C. Greece has also been cultivating it since 5th century B.C. In India, Almond is mostly cultivated in region of Kashmir where it is considered one of the chief crops [3].

1.3. Demography/Location

Almond trees are commonly cultivated in hotter regions of the world having long summers including California, Persia, Spain, Italy, Morocco, Australia, Kashmir, India, Afghanistan, Armenia, and Pakistan. Almond production reaches upto 1.2 million metric tonnes during 2017 and 2018. California (USA) being major producer, produces about 81% almonds, followed by other countries including Australia (7%), Spain (4%), Tunisia and Iran (1%) [4].

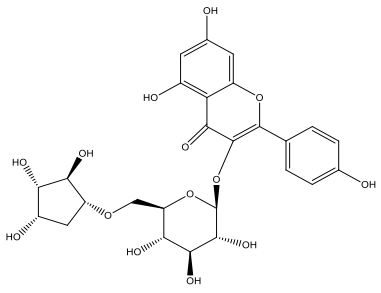
1.4. Botany, Morphology, Ecology

Almond being a small deciduous tree grows usually 4-10 m tall with 30 cm diameter of trunk. During first year of cultivation, the immature/young shoots appear green and change into purple color upon irradiation of sunlight, then in second year purple color changes to grey. Leaves are lanceolate, 3 to 5cm wide, 4-13cm long, having serrated

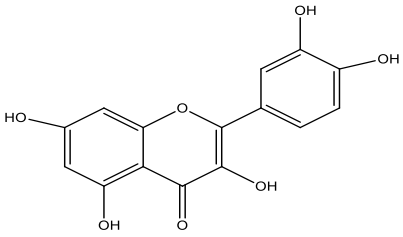
tips. Pale pink or white flowers having diameter (3-5cm), are produced singly or in form of clusters, in early spring. Fruit is 3.5 to 6.0 cm long drupe, having soft outer cover. In other *Prunus* members including cherries and plum, the exocarp is reduced to hull (leathery green-grey coat). Edible fruit (nut) is present inside hull. Wild almond fruit contains glycoside amygdalin, which after chewing or crushing changes to hydrogen cyanide. Conversely, the cultivated almonds are not poisonous [5]. Almonds can thrive best in well-drained soil of light to medium texture. Poorly drained or heavy soils are not good for almond's growth.

2. Chemistry

Prunus amygdalus L. mainly comprises of carbohydrates, protein, calcium, fats, iron, phosphorous, oxalic acid, folic acid, thiamine, riboflavin, nicotinic acid, magnesium, potassium, sodium, sulphur, copper, iodine and chlorine [3]. Almond is considered to be a potent source of tocopherols (vitamin E), fatty acids (monounsaturated and polyunsaturated) and arginine [6]. Its most active components include amino acids (histidine, arginine, phenylalanine, tryptophan, cystinine, lysine, methionine, tryptophan, valine and leucine) and globulins (albumin and amandine). Figure 1 shows structures of some important chemicals found in almond. Approximately, 49% oil is present in almond which has been reported to contain diolein (62%) and triolein (24%). Characterization of oil is generally carried out with the use of GC-MS analysis [7-10]. Seed coats contain flavonol glycosides including isorhamnetin glucoside, kaempferol glucoside, rutinoside, isorhamnetin and ckaempferol [11]. Furthermore, almond by-products are reported to contain phenolic constituents such as vanillic acid, protocatechuic acid, 3'Omethylquercetin, catechin, 3Oβ Dgalactopyranoside, 3Oα Lrhamnopyranosyl and phydroxybenzoic acid [12].



kaempferol-3-xylosylglucoside



Quercitin

Fig. 1. Structures of important bioactive constituents found in *Purunus amygdalus* L.

3. Post harvesting technology

Harvesting, storage, and processing strategies influence greatly the eating quality of almonds. Almond kernels (mostly one, eventually two) develop within the hard shell surrounded by the outer coat (hull). After maturity of kernels, the outer coat dries and split open, which allows natural drying of nut before harvesting. Harvesting should be done when kernel fully matures because in premature harvesting hull remain tightly stick to nuts and nuts dislodging will require more energy. Before harvesting, sheets of polythene should be placed under almond trees, to avoid nuts loss. Almonds are generally harvested manually, but in USA, farmers prefer mechanical tree shakers. Mechanical shakers are not used for young trees to avoid the risk of injury, instead they are harvested manually. After harvesting, kernels are spread to ground to dry for 8 to 10 days. After drying, they are passed through the series of rollers or transported to hull-sheller facilities to remove shell from kernels [13]. Dehulled kernels can be stored for a period of 6 months in a dry, cool, and well ventilated place.

4. Processing

All forms of almonds (roasted, raw, and sliced) are being used by consumers. They are mostly consumed as snacks and are used in making variety of sweet (cereals, biscuits, and cakes) and spicy (salads, tajines, and curries) dishes. Techniques used for almond's processing include: roasting, blanching, particle size reduction, and oil extraction. Roasting is a heating process which causes dehydration of almonds [14]. Different roasting methods are used to obtain light, dark or medium almonds depending upon moisture contents and color of resulting roast. Roasting reduces moisture contents. Roasting process should be performed under specific conditions to avoid oxidation of almond's fat contents. Blanching is done to reduce contamination caused by microbial growth. This thermal technique uses dry and wet methods to remove skin of almonds. Blanching reduces the nutritional quality of almonds because it involves removal of skin which contains essential phenolic constituents and flavonoids. Moisture content of blanched almonds is higher, when compared to roasted almonds [15]. Roasted and blanched almonds can be processed further to reduce their shape and size, which can be done by chopping, grounding, or slicing the almonds. Small size particles release more nutrients as compared to larger particles because of presence of more fractured cells. Generally, cold pressing method is used for almond oil extraction from kernels. Other methods involving solvent extraction (SE) and supercritical fluid extractions (SCFE) are also being used for the extraction of almond oil. Cold press extraction provides high quality oil, although, yield is lower as compared to other methods.

5. General uses

Almonds have wide variety of uses ranging from culinary to medicine. Mixture of ground almond and sugar (marzipan) is used in cakes and confectionary. Almond's

rich creamy butter can be used as an alternative to dairy butter. Almond milk is an alternative to cow's milk which can be used by the individuals having intolerance to lactose or allergic to proteins of cow milk. Almond oil, tablets, paste, and decoctions are used in the treatment of various diseases. Almond is used to cure cerebral disorders including loss of memory, headache, and insomnia. Its oil is useful for brain dryness, renal infections, and bladder stones. Kernels are considered as laxative, anti-tussive, and cerebrotonic. Sweet almonds are used to mitigate nephralgia, cystitis, and urinary disorders. Bitter almonds are used to cure uteralgia and hysteria. Roots decoction is used to treat pityriasis. Mixture of honey and almond is useful for wound healing. Almond hull powder is used to enhance tooth strength and shining. Mixture of almond oil and hot water is useful for sore throat.

6. Pharmacological Uses

6.1. Hepatoprotective Activities

A study was performed to investigate hepatoprotective effect of *Prunus Amygdalus* L. Model animals (rats) were first treated with almond and then with CCl_4. Pretreatment of oil reduced the levels of ALT (alanine amino-tranferase), AST (aspirate amino transferase), ALP(alkaline phosphatase), LDH (lactate dehydrogenase), TC (total cholesterol), TG (triglycerides), MDA (malondialdehyde), and LDL (lipoproteins), significantly. In addition to this, remarkable increase in concentrations of GPx (glutathione), SD (superoxide dismutase), and catalase was observed [16].

6.2. Anti-depressant effect

Depression is a disorder characterized by the persistent feeling of sadness, and loss of interest in usual things. According to world health organization (WHO), approximately 21% of the world population is affected by depression. A study was performed to investigate the anti-depressant potential of almond and lavender oils, using forced swim and passive avoidance tests. Male Wister mice having body weights in the range of 250-300 g were used as model animals. Almond oil (3.2g/kg) was administrated orally. Lavender oil inhalation was given to model animals for 30-60 minutes. Significant anti-depressant effects were observed in rats after combined therapy [17].

6.3. Antioxidant activity

Phenolic and flavonoid contents are generally responsible for the antioxidant activities of the plant [9-18-19]. A comparative study was carried out to investigate the free radical scavenging and anti-oxidant activities of phenolic extracts of almond shells and hulls. Almond fruits were collected and dried. Shells and hulls were ground to prepare methanolic extracts. FC (Folin-Ciocalteu) technique was used to determine TP (total phenolic contents). Antioxidant and anti-radical activities of extracts were evaluated against hydrogen peroxide, nitrite, and superoxide radicals. The shell and hull extracts had a range of (46.6 ± 0.94-18.1 ± 0.15 and 122.2 ± 3.11-75.9 ± 1.13 mg/g eq. of gallic acid) in TP, (0.267-0.114 and 0.667-0.343 AU at 700nm) in antioxidant power, (60.7 ± 2.13 % and 90.6 ± 1.11%) in superoxide, and (53.4 ± 0.86 % and 85.2 ± 1.21%) in nitrite antiradical %age, respectively. Results revealed the greater anti-radical and anti-oxidant potential of almond hull, when compared to shell [11].

6.5. Memory enhancing effect

A study was performed to investigate memory enhancing effect of *Prunus Amygdalus* L. nuts in scopolamine based amnesia in rats. *Prunus Amygdalus* L. nuts were orally administrated at three different dose levels (0.15, 0.3, and 0.6g/kg) in rats, for seven to fourteen days, using EPM (elevated plus maze), motor activity, and passive avoidance models. Piracetam at dose level of 0.2g/kg was used as reference drug. Brain's Ch E activity of rats was decreased after treatment. Furthermore, levels of TG (triglyceride) and (TC) total cholesterol were reduced and glucose level was increased [20]. In another investigation, memory improving effect of almonds paste was evaluated using EPM (Elevated plus Maze) and RAM (Radial Arm Maze) assays. Oral administration of almond paste in rats for 28 days significantly enhanced learning and memory parameters of model animals [21].

6.6. Anti-aging Activity

In a previous investigation, the Prunus amygdalus L. extract (skin) was used in herbal formulation and examined for skin protection from photo-aging caused by ultraviolet radiations of sun. Significant antioxidant activity was shown by the mice skin after treatment, as level of malondialdehyde (MDA) was decreased. While, Glutathione (GSH) level increased after treatment [22].

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