Review paper
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HEALTH PROPERTIES OF ALMOND

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Abstract

It is believed that almond is rich in terms of vitamin E, copper, phosphor, manganese, magnesium, potassium, fiber, riboflavin, monounsaturated fatty acids and protein. Because of its special composites of antioxidants such as: isorhamnetin, quercitrin, kaempferol, quercetin, catechin, epicatechin, naringenin, cyanidin, delphinidin, 3-O-rutinoside, isorhamnetin 3-O-glucoside, morin, caffeic acid, ferulic acid, p-coumaric acid, protocatechuic acid and vanillic acid, it is stated that almond is in special position in terms of human nutrition.

Antioxidants have a significant impact on DNA's damage inhibition as preventing LDL cholesterol oxidation. In numerous researches which have been studied about almond's effects on human health, the fat and fatty acids composition of almond's varieties have been determined and it has been expressed that almond: is rich in respect to monounsaturated fatty acids, it has oleic acid which is one of fatty acid that has the role of reducing cholesterol level in blood, and it has linoleic acid which prevents intravenous restriction. Almond is the best source among other nuts in terms of vitamin E which is known as the soluble lipid phenolic antioxidant. It has been indicated that vitamin E has an important role in order to prevent diabetes, atherosclerotic vascular diseases and some of cancer diseases. Further, almonds have a low glycemic index and do not adversely impact insulin sensitivity. While benefits of almonds for cardiovascular health and obesity-related diseases appear promising, the potential allergenic reaction among susceptible individuals can present a risk. L-Arginine in almond has been shown to be a powerful mediator of multiple biological processes, including the release of several hormones, collagen synthesis during wound healing, antitumour activity and immune cell responses. Almond oil is used today by massage therapists for its many natural emollient and skin-rejuvenating properties. Moreover, it may have a beneficial effect in the management of irritable bowel syndrome. Besides, almond is a good source of mineral compounds particularly: calcium, magnesium, phosphorus and potassium. These compounds have important contributions to human health in terms of balancing the hypertension, comprising the bone and teeth, blood forming, nerve stimulation, growth and gender development and muscular tissue activity.

Researches which have been studied on almond's nutritional aspects, support the approach that almond is a functional nutrient which has a medical benefit on treatment of some diseases.

***Key words**: Almond, Human health, Nutrition, Antioxidants, Fat, Fatty acids, Minerals.*

1. Introduction

Due to their rich content of energy, protein, minerals, vitamins, fats and fatty acids, almost all nuts species are considered as highly valuable foods in human diet. In numerous studies on nutrient compositions of nuts, many nut species were classified as functional foods.

In comparative studies on contents of protein - one of the essential nutrients and vitamins and minerals, pistachio, almond and walnut were reported to have richer protein content than that of meat, known to be richest source of protein. Pistachio (19.3%) has the highest protein content followed by almond (18.6%), walnut (14.8%) and hazelnut (12.6%). The protein content of beef is about 13.6%. The fat contents of nuts species are also higher than that of meat. Superiority of nuts in terms of mineral and vitamin contents and calories is particularly more evident (Table 1). Studies suggest that consuming about a handful of nuts per day provides most of the essential nutrients for human

body. Additionally, the relationship between nuts and diseases is revealed and studies on this topic are growing day by day. Almond is one of the valuable fruits among nuts species.

Table 1. Nutrient composition per 100 g of: pistachio, almond, hazelnut, walnut and beef

100 g	Pistachio	Almond	Hazelnut	Walnut	Beef
Protein (%)	19.3	18.6*	12.6	14.8	13.6
Fat (%)	53.7	54.2*	62.4	64.0	41.0
Carbohydrate (%)	19.0	19.5*	16.7	15.8	-
Ca (mg)	131.0	234.0*	209.0	99.0	8.0
P (mg)	500.0	504.0*	337.0	380.0	124.0
Fe (mg)	7.30	4.7*	3.4	3.1	2
K (mg)	972.0	773.0*	-	450.0	355.0
Vitamin A (IU)	230.0	5.00**	-	30.0	80.0
Vitamin B1 (mg)	0.67	0.24**	0.46	0.23	0.06
Vitamin B6 (mg)	1.40	0.13**	0.90	0.90	3.30
Calories	597.0	598.0*	634.0	651.0	428.0

Legend:
* According Özcan [2], Ayaz [3]
** According Chen *et al*., [1].

Almond has been investigated in many studies due to its nutritional properties and their effects on human health and its functional characteristics (Kurlandsky *et al*., [4], Mandalari *et al*., [5], Pandey and Rizvi [6], Rajaram *et al*., [7], and Wien *et al*., [8]). Besides being a functional food and food component, almond is considered to be a rich source of carbohydrate (20 g/100 g), energy (2418 kJ/100 g), protein (22 g/100 g), minerals (K, P, Mg and Ca), fats (51 g/100 g), monounsaturated fatty acids (MUFA) (32 g/100 g) and vitamin E (25.87 mg/100 g α-tocopherol), and a sufficient source of vitamins B1 (0.24 mg/100 g), B2 (0.8 mg/100 g), B3 (4 mg/100 g), B5 (0.3 mg/100 g), and B6 (0.13 mg/100 g). In addition, almond is reported to be significant for human diet due to its content of diabetic fibers (11.80 g/100 g), phytosterols (120 mg/100 g) and special combinations of antioxidant phenolics (Halliwell [9], Spiller *et al*., [10], Chen *et al*., [11], Ros [12], and Ahmad [13]).

Similar to other types of nuts, almond is also reported to have beneficial effects on coronary heart disease risk factors (Hyson *et al*., [14]). Almond effectively lowers LDL-cholesterol levels due to its rich content of dietary fibers and cardio-protective compounds: protein, arginine, α-tocopherol, magnesium, copper and potassium (Berryman *et al*., [15]). L-arginine has been shown to improve wound healing by stimulating collagen synthesis and release of several hormones and to have strong antitumor activity and immune-boosting property (Tomas-Cobos *et al*., [16]). High vitamin E content in almond has been reported to effectively lower plasma LDL-cholesterol levels. Compared to almond oil, almond fruit is more effective in reduction of cholesterol and LDL-cholesterol oxidation (Hyson *et al*., [14], Chen *et al*., [11]). Almond has also been reported to have a strong free radical scavenging mechanism due to the flavonoids and other phenolic compounds in the seed membrane and outer green shell cover. Almond green shell cover (outer cover) is highly rich in: triterpenoids, betulinic, urosolic and oleanolic acids (Takeoka *et al*., [17]), flavonol glycosides and phenolic acids (Wijeratne *et al*., [18]). It also contains protocatechuic acid, vanilic acid, p-hydroxybenzoic acid and naringenin glycosides (Sang *et al*., [19]). In their study, Li *et al*., [20] suggested that as a good antioxidant source, almond reduces smoking related biomarkers of oxidative stress. Despite their high content of fat, almonds are low glycemic foods and therefore, are suggested to be a part of the diet in patients with diabetes (Chen *et al*., [1]). In a study on health individuals, daily consumption of 100 g almonds for 4 weeks was reported to have no effect on insulin sensitivity (Lovejoy *et al*., [21])

2. Almond content and health

2.1 Fat and fatty acid content of almond

Almond is a rich source of fat and fatty acids. In the study of Ros [12], on almond and other nuts, fat content of almond was reported as 50.6%, saturated fatty acid content was reported as 3.9%, MUFA content was reported as 32.2% and polyunsaturated fatty acid (PUFA) content was reported as 12.2%.

Yildirim *et al*., [22] reported that total fat content in almond varieties changes from 50.9% ('Picantili') to 63.18% ('Cristomorto'), and respectively decreases in varieties: 'Supernova', 'Ferragnes', 'Ferraduel', 'Desmayo Largueta', 'Texas', 'Sonora', 'Ferrastar', 'Tuono', 'Nonpareil', 'Laurenne', 'Glorieta', 'Masbovera'.

Almond is rich in MUFA and PUFA with a content of 61.60% for the former and 29.31% for the latter (Venkatachalam and Sathe, [23]). Of the fatty acids, oleic acid reduces blood cholesterol level, linoleic acid prevents constriction of blood vessels, linolenic and linoleic acids reduce blood lipid and glyceride levels and hypertension. Compared to the other nuts species, hazelnut (83.10%) has the highest MUFA content and walnut has the highest PUFA content (72.96%). High-fat diets containing high amounts of MUFA are more recommendable compared to no-fat diets, since the latter increases plasma triglycerol levels and decreases HDL cholesterol levels, posing risk for heart diseases. The replacement of carbohydrates and saturated fats with MUFA lowers triglycerol. Almond-enriched high MUFA diet has been reported to have beneficial effects for human health (Rajaham *et al*., [7]).

In some of the studies on fatty acid composition of wild almond species, palmitic acid was established between 4.58 - 9.48% and stearic acid was established between 1.0 - 3.02% (Kiani *et al*., [24]). Palmitic, oleic and linoleic acid contents of varieties: 'Wood Colony', 'Monterey', 'Padre', 'Butte', 'Nonpareil', 'Carmel', 'LeGrand', 'Fritz', 'Mission', 'Price', 'Sonora', 'Ne Plus Ultra' and 'Aldrich' were found respectively between 5.0 - 6.4%, 64.7 - 76.0% and 16.3 - 26.9% (Gradziel *et al*., [25]). Askin *et al*., [26] stated that East Anatolia region of Turkey has rich genetic resources of almond which contain 50.41 - 81.2% oleic, 6.21 - 37.13% linoleic, 5.46 - 15.78% palmitic, 0.80 - 3.83% stearic and 0.36 - 2.52% palmitoleic acid. Özcan *et al*., [27] reported oleic acid content in varieties: 'Ferragnes', 'Tuono', 'Guara', 'Cristomorto' and 'Nonpareil' respectively as: 75.21%, 77.14%, 78.27%, 79.97% and 72.5%, linoleic acid content respectively as: 18.12%, 16.24%, 15.11%, 13.52% and 19.77%, palmitic acid content respectively as: 6.01%, 5.87%, 6.27%, 6.01% and 6.73%, palmitoleic acid content respectively as: 0.53%, 0.58%, 0.27%, 0.18% and 0.82%.

Almond is also a rich source of phytosterols. Phytosterols are found in the free form or esterified to fatty acids, phenolic acids or glycosides (Quilez *et al*., [28]). Sterols are reported to lower blood cholesterol levels and to have anticancer and immune-boosting properties (Award *et al*., [29], Plat and Mensink, [30]). Almond contains 143.4 mg/100 g β-sitosterol, 4.9 mg/100 g campesterol, 5 mg/100g stigma-sterol, and 19.7 mg/100 g Δ^5-avenasterol (Philips *et al*., [31]). Human body uses animal originated foods, as well as the candle like substance, cholesterol found in all body cells to produce bile acids that digest vitamins and fats. Higher than optimal cholesterol increase the risk of cardiovascular diseases. Berryman *et al*., [15] stated that almond consumption reduces total blood cholesterol and LDL-cholesterol levels while increasing HDL-cholesterol and triglyceride levels. HDL/LDL cholesterol ratio which is an important factor for atherosclerosis was observed to significantly increase with almond consumption. Mercanlıgil *et al*., [32] reported that almond-enriched high MUFA diet is preferable to low-fat diet due to the beneficial effects of the former on coronary heart disease risk factors.

2.2 Mineral content of almond

Almond is a rich source of minerals including calcium, magnesium, phosphor and potassium. Almond contributes significantly in: regulating blood pressure, bone and teeth development, blood production, nerve stimulation, activity of growth and sex hormones and healthy functioning of muscle tissue. 100 g almond contains about: 821 mg K, 586 mg P, 281 mg Mg, and 275 mg Ca (Saura-Calixto and Canellas, [33]). Ca content of almond (234 mg/100 g) is higher compared to those of other nut species (Ayaz, [3]). Almond contains 290 mg/100 g magnesium, and 4.1 mg/100 g manganese. In another study (Özcan *et al*., [27]), almond seeds were reported to contain 7.94 - 9.38 mg/100 g potassium, 2.9 - 4.0 mg/100 g magnesium and 1.84 - 2.94 mg/100 g calcium.

Selenium, one of the minerals found in almond, bounds to the proteins to produce selenoproteins which are important antioxidant enzymes. The antioxidant properties of selenoproteins help prevent cellular damage from free radicals, which in turn helps prevent the development of chronic diseases like cancer and heart diseases. Alasalvar and Shahidi, [34] reported that almond contains 1.06 µg/42.5g Se.

Almond is also a significant source of the essential mineral, copper. Copper plays a key role in hematopoiesis (production of blood cells). Diets that are poor in copper have negative effects on lipids, glucose tolerance and blood pressure. Magnesium in almond is important for maintaining calcium-potassium balance. Potassium found in almond has an important role in lowering blood pressure. Compared to hazelnut, pistachio and walnut, Italian almonds have the second highest K (780 mg/100 g) content after that of pistachio. Almond has the highest Ca and P contents and the third highest Fe content after those of pistachio and hazelnut (Fidanza, [35]). Hui-Guang *et al*., [36] reported that increased intake of potassium and decreased intake of sodium are important nutritional mechanisms for controlling hypertension. Hypertension, which is one of the most common health problems worldwide, can be lowered by controlled consumption of Na and K. In this respect, limited intake of sodium and consumption of potassium-rich foods like almond are suggested to significantly contribute in maintaining the balance (Hui-Guang *et al*., [36]).

2.3 Phenolic compound content of almond

Long term epidemiological studies have shown that polyphenol-rich diet has protective effects against: cancer, cardiovascular diseases, diabetes, osteoporosis, neurodegenerative diseases and aging (Graf *et al*., [37]; Arts and Hollman, [38]). Nuts species are good sources of phenolics. Total phenolic content of almond (239 mg GAE/100g) is lower than those of walnut, pecan and pistachio and higher than those of cashew, Macadamia hazelnut and Brazil chestnut (Kornsteiner *et al*., [39]). Oliver Chen and Blumberg, [40] stated that walnut (16.3 mg GAE/g) is the nuts species with the highest total phenolic content followed respectively by pecan (12.8 mg GAE/g), pistachio (8.7 mg GAE/g), peanut (4.2 mg GAE/g), hazelnut (2.9 mg GAE/g) and almond (2.4 mg GAE/g). Another study suggested that almond (4.18 mg GAE/g total phenolics) comes after pecan, pistachio and walnut with respect to total phenolic content and total phenolic content in almond oil is the lowest (168 mg GAE/kg oil) compared to those of other nuts species

(Alasalvar and Shahidi, [34]). Catechin (11.1-227.2 µg/g) was the most predominant phenolic compound identified in almond, followed respectively by caffeic acid (2.9 - 32.1 µg/g), epicatechin (2.0 - 23.5 µg/g) and gallic acid (2.4 - 16.1 µg/g) (Yildirim *et al.*, [41]).Total phenolic contents in almond varieties: 'Butte', 'Carmel', 'Fritz', 'Mission', 'Monterey', 'Nonpareil', 'Padre' and 'Price' were established between 127 - 241 mg GAE/100 g (Milbury *et al.*, [42]). ~80% of almond phenolics were found to be predominantly distributed within the "seed skin" at about 47 mg GAE/100 g (Kornsteiner *et al.*, [39]). Total phenolic content of kernel was reported as 0.07 phenolg/100 g (Venkatachalam and Sathe, [23]) and the most predominant phenolic in seed skin was stated as dihydroxykaempferol (50.8%), followed respectively by eriodictyol (48.7%), isorhamnetin (47.2%), quercetin-3-O-rutinoside (43.7%), quercetin-3-O-galactoside (41.4%), kaempferol-3-O-rutinoside (40.4%), kaempferol-3-O-glucoside (39.0%), kaempferol-3-O-galactoside (36.4%), catechin (35.7%), isorhamnetin-3-O-galactoside (35.0%), naringenin (34.1%) and epicatechin (33.9%) (Milbury *et al.*, [42]).

2.4 Vitamin content of almond

Recently, there have been growing numbers of studies on vitamin composition of almond. These studies suggest that almond contains fat soluble vitamins A and E and water soluble vitamins: B1, B2, B6, C, folic acid, pantothenic acid and niacin. Almond, following vegetable oil, is one of the good sources of vitamin E, a soluble lipid phenolic antioxidant. The antioxidant Vitamin E is known to slow down the progression of Alzheimer's disease, boost immune system, support cell growth and speed up cell regeneration, prevent coronary heart diseases, protect against cancer, protect against anemia by preventing breakdown of red blood cells and speed up post-infection cleaning of microorganisms from blood (Ayaz, [3], Singh and Jialal, [43]). Compared to other nuts species, almond has the highest content of riboflavin (0.4 mg/100 g), niacin (3 mg/100 g) and vitamin E (26 mg/100 g) and the lowest content of thiamin, vitamins A and C (Fidanza, [35]).

The human body needs folic acid (vitamin B9) for production of nucleic acids and conversion of some amino acids (conversion of serine, glycine and homocysteine to methionine, catabolism of histidine to glutamic acid) (Jacob, [44]). Folic acid deficiency, similar to vitamin B12 deficiency, causes megaloblastic (macrocytic) anemia (a deficiency in healthy, fully-matured red blood cells) especially in pregnant women and is supposed to have a role in the development of notably colon, stomach and uterus cancers and cardiovascular diseases due to increased serum homocysteine levels (Benoist, [45]). Folic acid content of nuts species was established between 58 - 77 µg/100g (Ayaz, [3]) and almond was reported to have a folic acid content of 29 µg/100g (Chen *et al.*, [1]).

In the study of Ayaz, [3], it was suggested that almond contains: vitamin B1 (0.24 mg/100g), vitamin B2 (0.92 mg/100g), vitamin B3 (3.50 mg/100g), folic acid (64 µg/100g) and vitamin E (24.2 mg/100g). In the studies on tocopherol profiles of nuts, average α-tocopherol equivalent (α-TE) values from the highest to the lowest were listed as: hazelnut (33.1 mg/100 g) > almond (25 mg/100 g) > peanut (8.1 mg/100 g) > pistachio (7.3 mg/100 g) > pine nut (6.1 mg/100 g) > walnut (5.5 mg/100 g) > Brazil walnut (4.3 mg/100 g) > pecan (3.7 mg/100 g) > cashew (1.3 mg/100 g). Average α-tocopherol value in almond is 24.2 mg/100 g fat, â- and γ-tocopherol is 3.1 mg/100 g fat (Kornsteiner *et al.*, [39]). α-tocopherol value of local almond varieties grown in Morocco was established between 348.43 - 434.05 mg/kg fat, γ-tocopherol value was established between 7.04 - 13.97 mg/kg fat and δ-tocopherol value was established between 0.45 - 0.81 mg/kg fat (Kodad *et al.*, [46]). α-tocopherol value of some selected genotypes in Turkey ranges between 143.97 - 462.78 µg/g fat (Yildirim *et al.*, [41]).

2.5 Aminoacids

Almond is a significant source of amino acids, which are the building blocks of proteins. Almond is highly rich in: essential amino acids leucine (1137 mg/100 g), phenylalanine (819 mg/100 g) and tyrosine (713 mg/100 g), and non-essential amino acids glutamic acid (4232 mg/100 g), arginine (2095 mg/100g) and aspartic acid (1695 mg/100 g) (Calixto *et al.*, [47]). Arginine is a precursor to nitric oxide (NO), which is indirectly involved in many bioactivities with antioxidative and antiplatelet effects against risks of cardiovascular diseases (Wu *et al.*, [48], and Wells *et al.*, [49]). Arginine contents of nuts species from the highest to the lowest are listed as: walnut (13.80 g/100 g), Brazil chestnut (12.91 g/100 g), Macadamia hazelnut (12.53 g/100 g), hazelnut (12.51 g/100 g), pecan (12.45 g/100 g), and almond (10.09 g/100 g) (Venkatachalam and Sathe, [23]).

3. Conclusions

- Studies clearly demonstrated that almond, which is a part of healthy lifestyle, helps to maintain a healthy cholesterol level and contributes to enrichment of daily diet and improvement of overall health.

- Regular almond consumption regulates blood sugar and insulin levels which are related with hunger.

- The protein and dietary fibers in almond contribute to satiety, which makes almond an important component of diet.

- Almond is classified as a functional food with its protective effects against some diseases and beneficial effects on human health. Hence, it is considered to be of great value due to its nutritional properties and the use of its oil for treatment purposes.

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