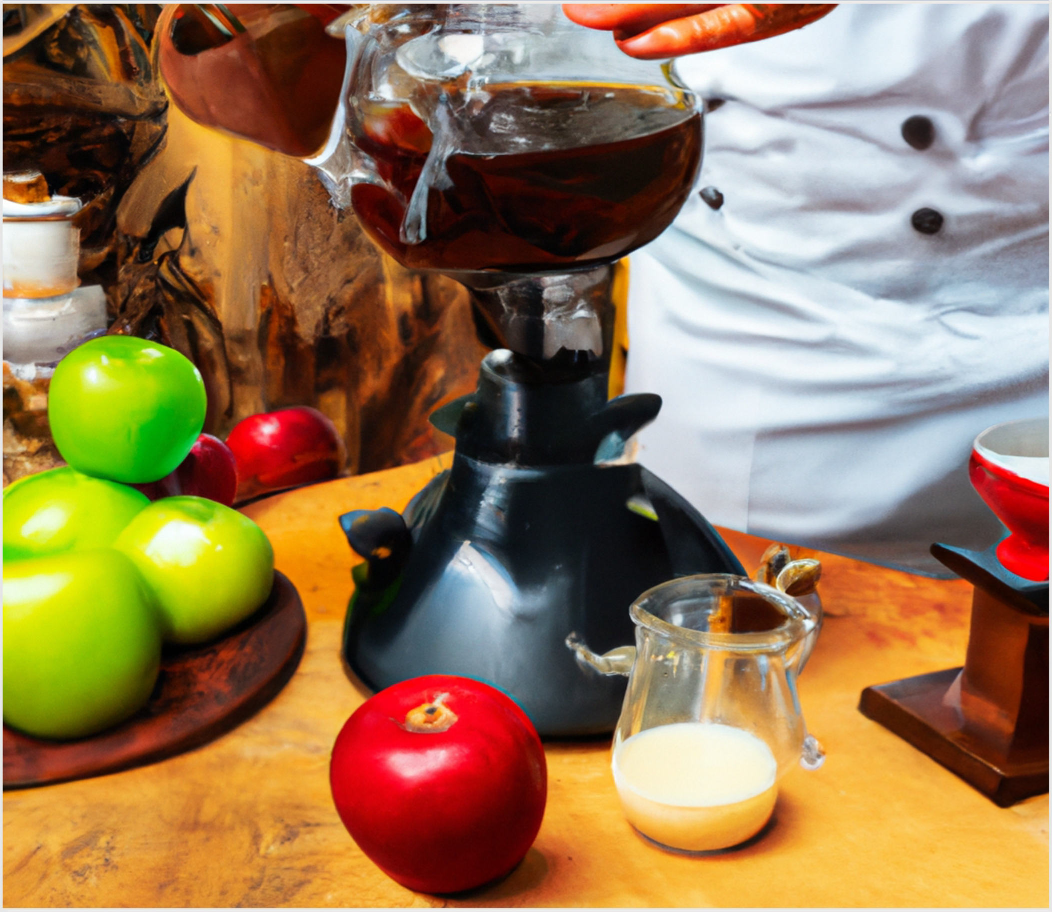
FRUITS FOR HUMAN USE IN VARIOUS ASPECTS



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Preface

Fruits are among the essential elements of human nutrition. Although the first definition that comes to mind when talking about fruit is "edible products of trees", in fact, fruit is botanically described as "the organ that is formed by the development of the ovary in plants after the fertilization of the flower and carries the seeds". In other words, we call fruit the organ that flowering plants form in different ways from the ovary and that develops with or without seeds. The importance of fruits in human nutrition is mainly due to the large/primary molecules such as carbohydrates, proteins, and fats they contain, the vitamins and inorganic minerals that people must take from outside, and the polyphenols, fatty acids, and organic acids, which are called secondary metabolites that have many important functions although they are small in quantity. Since each type of fruit can be rich in only some of the mentioned components, a varied diet in fruits is very important for a balanced diet. The beginning topics covered in this book are the nutritional values of fruits and the different organs of some species. Recognition and dissemination of new fruit species greatly contribute to the provision of a broader spectrum diet. Some of the studies that have been carried out and can be performed in this context have been included in the book. Again, the effects of fruits and their cultivation on the formation and development of culture in a region were examined. The different uses of fruits and the technologies developed in these areas are presented at the reader's intention. In conclusion, this book will be a resource helping the reader to consider fruit and fruit growing from various perspectives.

Emrah GÜLER

Editor

CHAPTER 1

CHEMICAL COMPOSITION OF ALMOND FRUIT

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1. Introduction

Nuts, macronutrients (fat, protein, carbohydrate), micronutrients (minerals and vitamins), fat-soluble bioactive substances (phospholipids, sterol esters, tocopherols, tocotrienols, phytosterols, phytosterols, terpenoids, sphingolipids and essential fatty acids) (phenolic acids, flavonoids, stilbenes, lignans, tannins or proanthocyanidins, carotenoids, alkaloids, phytates and phytoestrogens) are included in healthy nutrition recommendations (Cesarettin and Fereidoon, 2008). Nuts and by-products (bark, green leaves, stem and leaves) have antioxidant and free radical scavenging activity, anticarcinogenic, antimutagenic and antiproliferative potential due to their rich phytochemical content. Phytochemicals are protective against free radicals. It is protective against some types of cancer, coronary artery disease, stroke, atherosclerosis, osteoporosis, type 2 diabetes, inflammation, endothelial function, death and other neurodegenerative diseases associated with oxidative stress (Cesarettin and Fereidoon, 2008).

Nuts are among the foods with high energy density (Table 1). When nuts are roasted with oil, their total energy content increases. The total energy content increases by 30-40 kcal/100g due to the oil absorption of the nuts during the oil-roasting process (Brufau et al., 2006).

Table 1. Macronutrient content of nuts (g/100g) (Adapted from Dikmen, 2015)

	Raw			Roasted		
	Energy (kcal)	Protein	Fat	Energy (kcal)	Protein	Fat
Almond	579	21.2	49.9	598	20.9	52.5
brazil nuts	659	14.3	67.1	-	-	-
Cashews	553	18.2	43.8	574	15.3	46.4
Hazelnut	628	14.9	60.8	646	15.0	62.4
Macadamia nut	718	7.9	75.8	718	7.8	76.1
Pecans	691	9.2	72.0	710	9.5	74.3
Peanut	567	25.8	49.2	587	24.4	49.6
Pistachios	562	20.3	45.4	567	20.9	44.8
Walnut	654	15.2	65.2	-	-	-

Source: USDA

Nuts are a good source of vegetable protein and are rich in total protein content. Acidic amino acids (aspartic acid and glutamic acid) are nuts' most abundant amino acids (Cesarettin and Fereidoon, 2008). Nuts with a hard shell are very rich in arginine. Although the total protein content of nuts is high, some essential amino acid contents are limited. All nuts are limited to threonine (Brufau et al., 2006). The amount of isoleucine and lysine in the nuts is low. Methionine and cysteine are also low in nuts (mostly almonds). Histidine is high in all nuts (Cesarettin and Fereidoon, 2008). Foods with a high lysine/arginine ratio are associated with an increased risk of developing hypercholesterolemia and atherosclerosis. Nuts have a low lysine/arginine ratio. Because nuts are rich in arginine and poor in lysine, protein-rich foods such as nuts are high in arginine and glycine. These amino acids are suggested to reduce the risk of chronic degenerative disease due to their effect on insulin and glucagon levels (Brufau et al., 2006).

The main component of nuts is the total amount of oil. The amount of fat in these nuts depends on the fatty acid pattern, the soil in which they are grown, and the climate. Most nuts contain phytosterols and sphingolipids (Cesarettin and Fereidoon, 2008). The total fat content of nuts ranges from 46% (cashew, pistachio) to 76% (macadamia). However, the fatty acid composition of nuts is beneficial for health, the saturated fatty acid content is 4-16%, and almost half of the total fat content consists of unsaturated fatty acids (Table 2). Most the nuts are high in monounsaturated fatty acids (oleic acid). Brazil nuts contain monounsaturated fatty acids as well as polyunsaturated fatty acids (linoleic acid), pine nuts have more polyunsaturated fatty acids and less monounsaturated fatty acids, walnuts have more polyunsaturated fatty acids in the form of linoleic acid and α-linolenic acid (C18:3, n-3) (Ros and Mataix, 2006).

Table 2. The fatty acid pattern of nuts (g/100 g) (Adapted from Dikmen, 2015)

	Total fat	Saturated fatty acids	Monounsaturated fatty acids	Polyunsaturated fatty acids	18:2, n-6	18:3, n-3
Almond	49.9	3.8	31.5	12.8	12.3	0.00
Brazil nuts	67.1	16.1	23.9	24.4	23.8	0.02
Cashews	43.8	7.8	23.8	7.8	7.7	0.06
Hazelnut	60.8	4.5	45.7	7.9	7.8	0.09
Macadamia nut	75.8	12.1	58.9	1.5	1.3	0.21
Pecans	49.2	6.8	24.4	15.6	15.5	0.00
Peanut	45.4	5.6	23.8	13.7	13.5	0.26
Pistachios	72.0	6.2	40.8	21.6	20.6	1.00
Walnut	65.2	6.1	8.9	47.2	38.1	9.08

Source: USDA

It is metabolized in the body to linoleic acid, arachidonic acid, and n-6 eicosanoid. α-linolenic acid is metabolized to eicosapentaenoic acid and docosahexaenoic acid, followed by n-3 eicosanoid. n-6 eicosanoids increase platelet aggregation, are vasoconstrictors and are generally pro-inflammatory. eicosanoidsoids inhibit platelet aggregation and are vasodilators and anti-inflammatory. Therefore, the balance of n-6 and n-3 polyunsaturated fatty acids in the diet is an important factor affecting cardiovascular health. The ratio of n-6 fatty acids to n-3 fatty acids should be 4:1. Of all edible plants, walnuts have the highest α-linolenic acid content. The ratio of linoleic acid to α-linolenic acid in walnuts is about 4:1. Consumption of a sufficient amount of walnuts in our daily diet positively affects the production of eicosanoids and provides the balance of n-3/n-6 polyunsaturated fatty acids (Ros and Mataix, 2006).

The carbohydrate content of nuts varies according to their growing status, maturity of the seed, variety and place of cultivation (Cesarettin and Fereidoon, 2008). Nuts with a hard shell are also high in other nutrients. In addition to containing high protein and polyunsaturated fatty acids, it is also a rich source of various micronutrients and fiber (Table 3). Nuts with hard shells contain about 5-10 g/100 g pulp. Almonds (12.2 g/100 g), pistachios (10.3 g/100 g), and hazelnuts (9.7 g/100 g) have the highest pulp content, while cashews (3.3 g/100 g) have the lowest pulp content (USDA). Nuts are rich in minerals such as folic acid, niacin, vitamin E, vitamin B6, copper, magnesium, potassium, zinc, calcium, antioxidants, phytosterols and other phytochemicals (Sabate et al., 2006; Segura et al., 2006).

Table 3. Micronutrient composition of nuts (100 g) (Adapted from Dikmen, 2015)

	E vit (mg)	Folate (µg)	Niacin (mg)	B6 vit (mg)	Ca (mg)	Mg (mg)	Cu (mg)	Zn (mg)	Na (mg)	K (mg)
Almond	25.6	44	3.6	0.14	269	270	1.0	3.1	1	733
brazil nuts	5.6	22	0.3	0.1	160	376	1.7	4.1	3	659
Cashews	0.9	25	1.1	0.4	37	292	2.2	5.8	12	660
Hazelnut	15	113	1.8	0.6	114	163	1.7	2.5	0	680
Macadamia nut	0.5	11	2.5	0.3	85	130	0.7	1.3	5	368
Pecans	8.3	240	12.1	0.35	92	168	1.1	3.3	18	705
Peanut	1.4	22	1.2	0.2	70	121	1.2	4.6	0	410
Pistachios	2.3	51	1.3	1.7	105	121	1.3	2.2	1	1025
Walnut	2.1	31	0.5	0.6	61	201	1.4	3.4	2	523

Source: USDA

The edible part of the almond fruit, one of the hard-shelled fruits, is considered an important food product with high nutritional and medicinal value. The first records of the use of almonds in the field of health were found in ancient Greek, Persian, Chinese and Indian medicine (Albala, 2009). Almond was used as a thickener before the discovery of starch (Albala, 2009) and as a milk substitute (Mori et al., 2011) from the Middle Ages to the 18th century. While almond consumption was 1.452,206 tons in 2000, it reached 4.140,043 tons in 2020 and almost tripled in the last 20 years (FAO, 2022). This increase in almond production is due to its increasing use as a functional food and being a good snack food. Functional component or food is defined as “substances that have positive physiological effects on the human body depending on their composition, in addition to their known nutritional values.” Functional foods are generally classified into three groups: "functional ingredient," "functional ingredient added," and "undesirable compound removed" (Topçuoğlu and Ersan, 2020). Almonds are described as "foods containing functional components" because they contain sufficient amounts of daily nutrients, provide calories, regulate appetite, and prevent and treat especially cardiovascular diseases, obesity and some cancer diseases (Dikmen, 2015). Almonds can be consumed raw or roasted, blanched or unbleached, alone or mixed with other nuts. It can also be made into different forms, incorporated into other products, or used to produce marzipan and nougat (Schirra, 1997). The high lipid content of almond seeds, an important source of calories, increases their high nutritional value. However, high levels of unsaturated fatty acids, especially monounsaturated fatty acids, do not cause cholesterol formation in humans (Sabaté and Hook, 2000).

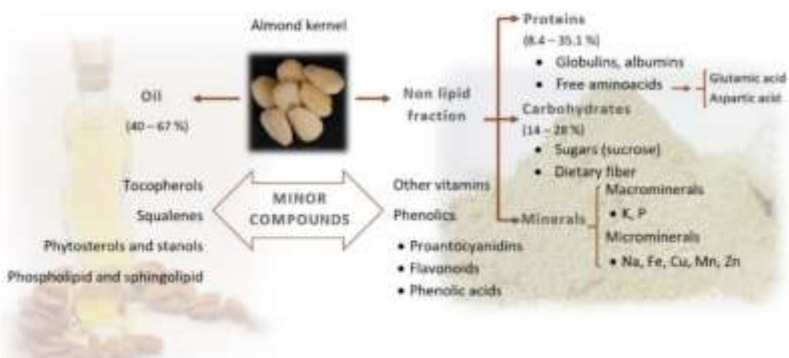

Figure 1. Chemical composition of the almond kernel (Roncero et al., 2020).

Almonds must be of high quality to both appeal to consumers and meet the needs of the industry (Socias i Company et al., 2008). When industries such as pastry, confectionery and cake are taken into account, the chemical composition of the fruit comes to the fore, as well as the physical properties of almonds (Figure 1). As with other nuts, the first feature that comes to mind when talking about the chemical composition of almonds is oil. In addition to the oil, which is one of the quality criteria of the kernel, the percentage of oleic acid in the lipid fraction of the fruit, the oleic/linoleic acid ratio (O/L) and tocopherol concentration are also the properties sought in the quality criteria of the kernel (Kodad and Socias i Company, 2008; Socias i Company et al., 2008). Cultural practices (Yada et al., 2011), cultivars characteristics (Kodad et al., 2011a; Summo et al., 2018; Roncero et al., 2020), geographical location (Abdallah et al., 1998; Kodad et al., 2011a) and ecological factors (Barbera et al., 1994; Kodad et al., 2011b) are effective on the chemical composition of almonds. This section summarizes the chemical composition of the kernel (the edible part) and information about the factors affecting these variables.

2. Lipid Content and Fatty Acid Profile

Almond, a rich source of lipids, contains mono and polyunsaturated fatty acids (Sabaté and Hook, 2000). Lipid fraction is also an important determinant of flavor, especially after roasting (Socias i Company et al., 2008). The fat fraction in the inner almond consists mainly of storage lipids found as intracellular fat droplets (about 1-3 mm in diameter) in the cotyledonous tissues (Pascual-Albero et al., 1998; Ren et al., 2001). For several months after the fruit set, the oil content of the inner almond is low (< 10% of dry matter) but then increases rapidly until about one month before harvest and then continues to increase gradually (Saura-

Calixto et al., 1984b; Kumar et al., 2000; Egea et al., 2009) or remains constant (Cherif et al., 2009). The high-fat content of almonds is a desirable event for the confectionery industry. Because the high-fat content causes less water absorption by the almond paste (Alessandroni, 1980). On the contrary, almonds with low-fat content are preferred to produce almond milk, a dietetic product (Fasoli et al., 2011). Almond oil content generally depends on genotype, but according to years (Abdallah et al., 1998; Sathe et al., 2008; Kodad et al., 2011a) and growing conditions (Kodad et al., 2010; Kodad et al., 2013). They are reported to show high variability. However, Zhu et al. (2015) reported that moderate irrigation had no detrimental effect on the lipid content of almonds, but severe and extreme deficiencies did affect the lipid content. It has been reported that almond oil is very rich in monounsaturated fatty acids (MUFAs), especially oleic and linoleic acids, and very low in saturated fatty acids, especially palmitic, palmitoleic and stearic (Yada et al., 2011) (Table 4). These five fatty acids make up more than 95% of the total lipid fraction, depending on the variety, and eight minor fatty acids have also been reported (Martín-Carratalá et al., 1998). The degradation of fatty acids to peroxides affects the quality of almonds, resulting in a bitter taste (Harris et al., 1972). Fat oxidation is affected by various factors, such as the percentage of unsaturated fatty acids, light, oxygen, metallic ions, temperature, and enzymes (Gou et al., 2000; Zacheo et al., 2000).

The fatty acid profile is considered the most interesting topic in the oil oxidation process. Kester et al. (1993) suggested that the oleic acid/linoleic acid ratio (O/L) is a good index of resistance to oil rancidity, and higher ratios are preferred. In other nut species, such as hazelnuts, the adopted criterion was the ratio of unsaturated fatty acids/to saturated fatty acids (Bonvehí and Coll, 1993; Peshern et al., 1995). Oleic and linoleic acid contents, important components of fatty acids, vary according to genotype and are affected by climatic (Kodad et al., 2011a; Maestri et al., 2015) and environmental factors (Sathe et al., 2008; Yada et al., 2013).

Table 4. Range of variability of significant almond macronutrients kernels (g/100 g Almond Kernel) (Adapted from Kodad, 2017; Roncero et al., 2020)

Nutrient	Range of Variability (g/100 g)	Origin	References
Oil content			
	40-67	Spain	García-López et al. (1996), García-Pascual et al. (2003), Kodad et al. (2006), Kodad et al. (2011a), Kodad and Socias i Company (2008), López-Ortiz et al. (2008), Romojaro et al. (1988), Sánchez-Bel et al. (2008) and Soler et al. (1989)
	56-61	Greece	Nanos et al. (2002)
	54.75-64.73	France	Kodad et al. (2011a)
	42-66.8	Italy	Kodad et al. (2011a), Barbera et al. (1994), Ruggeri et al. (1998) and Schirra and Agabbio (1989)
	48-63.9	Portugal	Cordeiro et al. (2001) and Egea et al. (2009), Kodad et al. (2011a)
	35-66	USA	Abdallah et al. (1998), Ahrens et al. (2005), Hall et al. (1958), López-Ortiz et al. (2008), Sathe (1992), Sathe et al. (2008) and Venkatachalam and Sathe (2006)
	57-63.9	Ukraine	Kodad et al. (2011a)
	63-66	India	Kodad et al. (2011a)
	48.7-64.5	Morocco	Kodad et al. (2013)
	48-66	Argentina	Kodad et al. (2011a), Maestri et al. (2015)
	20.19-62	Iran	Mehran and Filsoof (1974), Abaspour et al. (2012) and Kiani et al. (2015)
	56.1-59.8	Tunisia	Ayadi et al. (2006)
	48-61	Türkiye	Çelik and Balta (2011) and Askin et al. (2007)
	55-59	Egypt	Nassar et al. (1977)

Protein, total (N × 5.18)		
16.4–22.1	USA	Sathe, 1993
18.5–24.0	California	Yada et al., 2013
20.7–23.3	USA	Ahrens et al., 2005
15.8–25.1	Spain	Esteban, 1985
14.5–29.2	Spain	Kodad et al., 2011a
8.4–24.7	Spain	Font i Forcada et al., 2011
21.0–24.0	Portugal	Barreira et al., 2012
9.6–28.5	France, Italy and Greece	Drogoudi et al., 2013
20.0–32.8	Spain and Morocco	Kodad et al., 2011a
14.1–35.1	Morocco	Kodad et al., 2013
16.7–31.5	Türkiye	Askin et al., 2007
12.7–16.3	Türkiye	Ozcan et al., 2011
20.4–25.8	Türkiye	Simsek et al., 2018
11.52 ± 1.1	Nigeria	Agunbiade, 2006
23.8	India	Chung et al., 2013
20.0	South Africa	Moodley et al., 2007
17.36–23.02	Serbia	Čolić et al., 2020
Carbohydrates, total		
14–21	Portugal	Barreira et al., 2012
23.6–27	USA	Ahrens et al., 2005
28	Nigeria	Akpambang et al., 2008
28.0	South Africa	Moodley et al., 2007
Sugars, soluble		
2.6	Türkiye	Aslantas et al., 2001
1.8-7.9	Spain	Saura-Calixto et al., 1988
1.74–4.31	Greece	Kazantzis et al. (2003) and Nanos et al. (2002)
2.1-7.4	USA	Ahrens et al. (2005), Amrein et al. (2005), Venkatachalam and Sathe (2006)
3.6-12	Italy	Amrein et al. (2005), Barbera et al. (1994) and Ruggeri et al. (1998)
2.5-7.1	Portugal	Cordeiro et al. (2001) and Egea et al. (2009)
Sucrose		
2.5–5.1	California	Yada et al., 2013
1.42–3.62	Greece	Kazantzis et al., 2003
1.15–2.22	Portugal	Barreira et al., 2010

3.67–7.09	Spain	Sánchez-Bel et al., 2008
1.21–3.08	Portugal	Oliveira et al., 2019
Fiber, total dietary		
9.8	California	Mandalari et al., 2008
7.9–16	California	Yada et al., 2013
3.3–8.6	Spain	Kodad, 2006
4.73–6.01	Spain	Sánchez-Bel et al., 2008
11–14	Italy	Ruggeri et al., 1998

Table 5. Fatty acid profile and range of variability of almond kernel oil (Adapted from Kodad, 2017)

Fatty acid	Range of variability (% of total fatty acids)	Origin	References
Linoleic	12-22.5	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	15.4-35.1	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	12.6-27	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	19.2-22.4	Morocco	Kodad et al. (2013)
	11-23	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	11.9-24.4	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Oleic	68-77.5	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	57.4-77.3	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	64-80.6	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	68-70.7	Morocco	Kodad et al. (2013)
	65-77	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	67.6-80.8	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Palmitic	6.01-7.26	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	5.67-7.8	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	4.4-5.3	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	6.3-7.5	Morocco	Kodad et al. (2013)

	5.4-7.1	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	6-8.1	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)
Stearic	1.06-1.77	Argentina	Maestri et al. (2015) and Kodad et al. (2011a)
	1.1-2.6	USA	Abdallah et al. (1998), Sathe et al. (2008) and Kodad et al. (2011a)
	0.26-1.89	Türkiye	Askin et al. (2007), Karatay et al. (2014) and Çelik and Balta (2011)
	1.9-2	Morocco	Kodad et al. (2013)
	1.54–2.5	Spain	Prats-Moya et al. (1999), García-López et al. (1996), Soler et al. (1989), Kodad et al. (2011a) and Kodad et al. (2014)
	1-1.89	Iran	Kiani et al. (2015) and Mehran and Filsoof (1974)

3. Vitamins

Most of the studies on the vitamin content in almonds are related to antioxidants, which are effective in protecting the oil against oxidation and degradation. The most important of these are tocopherols. Tocopherols are natural monophenols (Reische et al., 1998). The main tocopherol homologues in almonds are α-, γ-, δ- and β-tocopherol. These compounds have a protective effect on biological systems with their hypocholesterolemic, anti-cancer and neuroprotective effects (Sen et al., 2007). In addition, the tocopherol concentration plays an important role in protecting lipids from oxidation, thus prolonging their storage time (García-Pascual et al., 2003).

The most active form of vitamin E is α-Tocopherol and is used in the human body in different ways than other forms (Brigelius-Flohé et al., 2002). The tocopherol concentration in almond oil varies according to the genotype and climatic conditions (Yada et al., 2013; Kodad et al., 2014; Maestri et al., 2015) and the environmental conditions (Kodad et al., 2011b; Yada et al. al., 2013) of the growing region.

As in many plants, the most important factors affecting chemical compounds in almonds are drought and heat stress. Kodad et al. (2006) emphasized a positive relationship between temperatures and tocopherols. Researchers reported higher tocopherol concentrations in almonds harvested at high temperatures. Maestri et al. (2015) also reported a similar relationship between high temperatures and tocopherol. Looking at the relationship between tocopherol and drought, Zhu et al. (2015) reported no significant relationship between tocopherol content and the degree of water deficiency.

Almonds are also a source of B1 (thiamine), B2 (riboflavin), B6 (pyridoxine), and niacin. Vitamin B6 plays an influential role in reducing the homocysteine level in the body, which has a harmful effect at high concentrations (Whitney and Rolfes, 2002). Processing almonds in different ways affect vitamin levels in various ways. Daud et al. (1977) reported that the vitamin B6 content of natural and processed almonds ranged from 0.08 to 0.16 mg/100 g. The same researchers reported that vitamin B6 in almonds decreased by about 12% after boiling and by 25% after roasting.

4. Minerals

Plants, like other living things, need various plant nutrients to survive. Plants absorb the elements they need from the air, water and soil. Some of these elements are the elements that the plant needs to grow and develop, and some are the elements that are beneficial for the growth and development of the plant. Each nutrient element helps different plant functions that enable the plant to grow and develop. Almond is one of the fruits considered important for human health thanks to its mineral elements. The ash content obtained from plant materials is expressed as the inorganic residue left over from burning plant tissue (Yada et al., 2011). As seen from the above, almond mineral contents may vary according to the soil cultivated and specific to varieties (Table 6). Almond is a source of calcium, magnesium and manganese (Yada et al., 2013; Mahmoud and Yasin, 2016). During the growth and maturation of the almond fruit, copper, iron, phosphorus, zinc and potassium accumulate (Schirra et al., 1994). Among these minerals, potassium is approximately four times more abundant than sodium (Mahmoud and Yasin, 2016).

Table 6. Mineral, vitamin and total phenolic contents in almond kernels (Adapted from Grundy et al., 2016; Richardson et al., 2009; Bolling et al., 2011; Yada et al., 2011, USDA)

	Range of Variability (mg/100 g)
Minerals	
Calcium	264–300
Magnesium	230–268
Phosphorus	440–510
Potassium	705–730
Zinc	3.0–4.1
Copper	0.9–1.3
Manganese	1.2–1.8
Vitamins	
Riboflavin	1.0–1.1
Vitamin E (α-tocopherol)	25–27
Total phenolic compounds	260–350

5. Protein and Amino Acids

After the lipid fraction, the second largest chemical component of almond kernels is protein (Gradziel, 2017). The main protein fraction identified in almonds is globulins and albumins, which make up 88-91% of the total protein (Saura-Calixto et al., 1982). The protein content is inversely proportional to the lipid fraction, and the balance in the ratio of these two compounds is important in preparing products such as marzipan (Alessandroni, 1980). The most common amino acids in almond proteins are glutamic acid, aspartic acid and arginine (Socias i Company et al., 2008). Essential amino acids constitute approximately 30% of the protein (Ruggeri et al., 1998). The protein and amino acid content in almonds varies according to the origin of the genotype and the climatic and environmental conditions of the growing region (Saura-Calixto et al., 1988; Kodad, 2006).

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6. Phenols

When the distribution of phenolic compounds in terms of factors affecting health worldwide is examined, it has been observed that the diet supported by vegetables and fruits prolongs the deformation time of the body and organs. However, it has a protective effect on many diseases such as cardiovascular diseases, inflammatory and rheumatic diseases in the bones of the hands and feet, diseases caused by the irregular division of cells, diseases caused by the lungs, and disorders in the eye (Szajdek and Borowska, 2008). Almond kernels are a good source of phenolic compounds (Bolling et al., 2010). Almond phenolics are mainly polyphenolics of the flavonoid type (Wijeratne et al., 2006; Bolling et al., 2010). It has been reported that almonds' total phenol and polyphenol content vary between 60.2-175.1 mg GAE/100 g and 14.6-27.2 mg/100 g, respectively (Kodad, 2006; Milbury et al., 2006; Bolling et al., 2010). Catechin is the main phenolic acid ranging from 11.1-227.2 μg/g, followed by caffeic acid (2.9-32.1 μg/g), epicatechin (2.0–23.5 μg/g) and gallic acid (2.4–6.1 μg/g) (Yıldırım et al. al., 2010).

Augustin and Unnithan (1981) determined that the total phenolic content of almond samples was severely affected during the ripening period. In other words, they concluded that the phenol content is higher in unripe fruits. Because phenolic compounds are used as secondary metabolites for the defense mechanisms of plants, thus, they allow young fruits to complete their developmental stages by protecting them in their maturation and reproductive functions (Maieves et al., 2015). Bolling et al. (2010) reported that flavonoids and total polyphenols depend on variety rather than environmental conditions.

7. Carbohydrates and Fibre

The only forms of carbohydrates found in almond kernels that can be digested, absorbed and metabolized by humans as energy sources are sugars, starch and some sugar alcohols (Gradziel, 2017). Non-starch polysaccharides are indigestible and, therefore cannot be used as an energy source, but they promote physiological effects that are beneficial for human health (Yada et al., 2011).

It has been reported that the soluble sugar content ranges from 1.8 g/100 g (Amrein et al., 2005) to 13 g/100 g (Balta et al., 2009). Most soluble sugars are non-reducing, and sucrose represents more than 90% of the total (Socias i Company et al., 2008). Other sugars include raffinose, glucose, fructose, sorbitol, and inositol (Schirra, 1997; Saura-Calixto et al., 1984a). Some investigators have reported that carbohydrates change during the development of the almond fruit, resulting in a drastic decrease in all sugars two months before harvest (Kazantzis et al., 2003; Egea et al., 2009).

Egea et al. (2009) reported that the main sugar component is sucrose in almonds at harvest, that glucose and fructose contents are insignificant at this stage, and that mannose and arabinose are not detected. Sánchez-Bel et al. (2008), in a study conducted with the cultivar 'Guara,' determined that the sucrose and glucose content of the fruits in the gardens irrigated with drip irrigation were higher than in the orchards that were not irrigated.

In addition to polysaccharides in almonds, there are 10 grams of dietary fiber in 100 grams of almonds (Socias i Company et al., 2008). Saura-Calixto et al. (1988) reported that this fiber positively affects colon health and cholesterol level. Almond fiber consists of cellulose, hemicellulose and lignin (Vidal Valverde et al., 1982).

8. Conclusion

Almonds, used as a by-product in many industries and for fresh consumption, contain many phytochemicals with potential health benefits. It includes a significant amount of quality protein, especially globulins, essential minerals and fiber with low sugar content. It has been reported that varieties, ecological factors, topography, cultural practices, climate and soil characteristics, and pre-harvest and post-harvest factors affect the nutritional content of almonds. However, to clarify the effects of almond phytochemicals on the quality and quantity, more profound studies are needed on drying, blanching, storage, roasting processes and their nutrient content as by-products, factors that cause changes under agricultural and environmental conditions, and especially genetic factors.

Standard methods used today make it difficult to extract and quantify almond phytochemicals. Increasingly, microwave, supercritical fluids and ultrasound-based methods have been used.

There are very few studies on the evaluation of non-lipid compounds derived from almonds. Accordingly, the nutritional composition of the non-lipid fraction of almonds, the by-products remaining after oil extraction, and the source of protein, fiber and mineral substances may be more involved in food applications.

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