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Effect on Human Health Components of Pine Nuts (*Pinus pinea*)

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Abstract

Pine nut (*Pinus pinea*), known in our country as "bell nut", is the seed of pine trees that contain high levels of oil, protein and minerals. Pine nuts are generally added to meals and desserts as a flavoring element, and can be consumed raw or roasted. Due to its beneficial effects on human health, it attracts the attention of both consumers and researchers.

In this review, brief information is given about pine nuts, its components and its effect on human health.

Keywords: Pine nut, fatty acid, protein, human health.

1. Introduction

Turkey has a rich biodiversity in terms of plant species and non-wood forest products. All kinds of animal and vegetable products grown in forests such as wild plants, medicinal plants, bulbous plants, aromatic plants, mushrooms and honey are among the non-wood forest products that meet the nutritional needs of living things, especially people [1]. In addition to its environmental functions, pine nuts in this product group also meet various needs of the society with other products that are produced as a result of its production [2,3].

Today, functional afforestation is carried out in developing and/or developed countries both for the purpose of wood production and by calculating by-products. In most European countries with a Mediterranean climate, peanut pine (*Pinus pinea L.*) is highly preferred in afforestation studies for the production of by-products due to its suitability to existing ecological demands and providing added value to the economy [4]. Pine nut, which is also among the livelihoods of the producing people, has very high potential values [5]. Pine nut (*Pinus pinea*) is the endosperm part of the seeds (kernels) of the pine nut trees belonging to the *Pinus* genus of the *Pinaceae* family, separated from the shell and membrane, with a pointed end, ellipsoidal shape [6]. In our country, pine nuts are also known by different local names such as “künar, küner, günar and püste”.

In addition to *Pinus pinea L.*, pine nuts are obtained from some *Pinus* species in the world. Korean pine (*Pinus koraiensis*) native to Northeast Asia, Chilgoza pine (*Pinus gerardiana*) native to Western Himalaya, pine native to Siberia (*Pinus sibirica*), Japanese pine (*Pinus pumila*), Chinese White pine (*Pinus armandii*), Mexican pine (*Pinus cembroides*), Bunge pine (*Pinus bungeana*), and Colorado pine (*Pinus edulis*) are known species [7].

Pine nut trees in the *Pinaceae* family have an area of approximately 700,000 ha in the world and show a natural spread in geographies with the Mediterranean climate, especially in Spain, Italy, Portugal, Turkey, Tunisia, Algeria, Morocco, Greece and Israel. Spain covers 75% of the natural spread, Turkey 9% and Italy 5% [8,9].

An average of 30,000 tons of consumable pine nuts are produced throughout the world, and while the average production is 27,975 tons/year according to 2004 data [10], it is 19,575 tons according to 2015 data [11].

In Turkey, pine nut trees have an area of approximately 100,000 hectares, primarily in İzmir-Bergama (Kozak) and Aydın-Koçarlı (Mazon) regions [11]. The average edible peanut production in our country is around 1,300 tons/year and [12] 900 tons of this amount is produced in İzmir-Kozak and most of the rest in Aydın-Mazon region.

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In our country, pine nuts are divided into 3 types as Aydın, Kozak and Maraş Types according to TSE standards. The classification is arranged according to the organoleptic and taste characteristics of peanuts. Kozak type; large, its body is full, soft, blunt, and its tip is cream-colored. Aydın type; Large and small, the body is less plump, brittle, very pointed, the tip is dark cream colored. If the Maraş type is; small, long-thin body, brittle structure, very sharp, the tip is dirty yellow [6].

2.Source Research

The stone pine (*Pinus pinea L.*) is a species belonging to the Pinus genus from the Pinaceae family and has a 20-25 m length, umbrella-shaped crown structure and monecious fertilization biology. Stone pine, which has a strong root system, develops a deep tap root system in fertile soils [13].

Although the flowering period of the stone pine varies according to the regions, it is in April-June. However, fertilization takes place until the next spring. The cone in the flowering period is the size of an average hazelnut and takes the name of a 1-year-old cone known as "ülker" (Figure 1). The color of the cone, which develops slowly until the next spring, starts to turn light brown and 2 old cones, also known as "red migratory", are formed in this period (Figure 2). The cone, which has a greatly increased water content since spring and turns green, fully matures in the autumn of that year and takes the name of 3 brown-colored old cones (Figure 3-4).

Stone pine start to keep cones at the age of 15, but trees that are 20-25 years old can be really economically productive. Cone yield reaches its maximum at 70-100 years of age [14].

According to the dispersion of stone pine in the world, it shows a very good development on calcareous bedrock [15]. In Turkey, it has been observed that stone pine trees, which develop primarily in sandstone, marlstone, mica schist and andesite bedrock, spread over sandy, lime, clayey, loose, and cool soils [16,17].

Stone pine trees are highly resistant to drought and are sensitive to winter frosts [17]. In a study that looked at the humidity and temperature requirements, it was reported that the stone pine grows in areas with a relative humidity of 70-80%, the temperature is not very low, an average of 22°C and receiving direct sunlight [18].

Figure 1. An old cone (Ülker) [77].

Figure 2. Two-year-old cones (Red migratory) [77].

Figure 3. Three-year-old cones [77].

Figure 4. Cones at harvest maturity [77].

Different forms of products are obtained and sold from stone pine, such as peanuts, shelled peanuts or cones. In this sense, physical quality characteristics are important. Physical quality parameters such as weight, aspect ratio, crack ratio, defective grain ratio, yield are important in pricing the product.

In the study conducted by Şen et al., 2016 [19] in Kozak, which is one of the places where pine nuts are produced the most in our country, the physical characteristics of the pine nut samples collected for 3 seasons were examined. According to the results obtained in the study, the length of the cone was 14,25 mm, width 5,48 mm, cracked cone ratio 26,99%, broken grain ratio 3,62%, moisture content 4,36%, water activity 0,45%, efficiency 27,73%, the number of cones in 100 g sample and the number of internal peanuts were reported as 138 and 498, respectively.

Similarly, in the study conducted by Örnek et al., 2015 [20] physical properties such as weight, length and width of the shelled pine nut samples and the kernel pine nut samples at different humidity values of the pine nuts collected from the Mut (İçel) region were examined.

2.1. Pine Nut Production

Pine nut production is carried out in two independent sections as seed and kernel pine nut production.

2.1.1.Shelled Pine Nut Production Steps

1. Collection of mature cones
2. Covering the collected cones with branches and keeping them waiting until summer
3. Drying the cones by loosening them under the sun
4. Separation of cone and seed
5. Screening of seeds
6. Drying and bagging of seeds.

The collection process is carried out between October of that year and February of the following year. The collection is done by hand or using hooked poles known as “kiye”. Then these cones are taken to the threshing floor and loosened under the sun and the seeds are separated from the cones. By separating the seeds from the cones that loosen under the sun, empty cones called "steel", cone carpels called "potlets" and shelled seeds called "kuner" are obtained.

Empty cones and caplets are used as fuel [21]. Seeds separated from the pods are separated from each other as full and empty according to their weight by using water pools.

The seeds that come out of the water pool are dried under the sun and then put into sacks [21].

2.1.2.Kernel Peanut Production Steps

1. Softening shelled peanut in water for 24 hours
2. Crushing shelled peanut by passing them through sieves
3. Pneumatic separation of shells and pine nut kernels
4. Sifting the pine nut kernels
5. Washing and sterilization
6. Drying and bagging of pine nuts.

The shell, called "kıpır", obtained as a by-product in the sieving process, can be used as fuel [21].

2.3. Uses Of Pine Nuts

Apart from being a good source of nutrients, pine nuts are used raw or roasted as a flavoring element in traditional dishes, vegetable and meat dishes, breads, confectionery, sauces and cakes. Peanuts, which can also be consumed fresh, are also mixed with honey and consumed as an energizer in the form of paste.

A light yellow, odorless oil is obtained by pressing the pine nuts. This oil is used both as cooking oil and in the manufacture of soap and varnish. The pulp released by the pressing process is used in confectionery and cosmetics industry [22].

3.Pine Nuts Composıtıon

Pine nut is a food rich in chemical composition like other nuts. Pine nuts, which have a high fat and protein content, are also a good source of vitamin B1, K and P minerals.

It is reported that pine nuts show 5,6% moisture, 31,1% protein, 47,4% fat, 10,7% carbohydrate and 4,3% ash composition. They contain various vitamins and minerals, especially B1 and B2, especially potassium and phosphorus. In addition to its nutritional value, the consumption of pine nuts is beneficial to health. It has been reported that regular nut consumption reduces the risk of both coronary heart disease and heart attack [23]. This effect is due to the fact that pine nuts contain high amounts of unsaturated fatty acids such as linoleic acid.

3.1. Chemical Composition

The chemical composition of pine nuts differs between species and even some subspecies, depending on ecological conditions [23,24].

In a study conducted by Nergiz and Dönmez, 2004 [12] the chemical composition and nutritional values of pine nuts from Kozak region were examined. Moisture 5%, ash 4,5%, fat 44,9%, protein 31,6%, carbohydrate 13,9%, water-soluble dry matter 5,15% and energy 583 kcal were reported in pine nuts (Table 1).

Table 1. Chemical composition and nutritional values of pine nuts [12, 78].

Chemical Composition	% Değer
Energy (kcal)	673
Moisture	5,10
Ash	4,50
Oil	44,90
Protein	31,60
Carbohydrate	13,90
Water Soluble Dry Matter	5,15
Reducing Sugar	0,70
Sucrose	4,30
Fiber	3,70

Low moisture content is important for maintaining the quality and shelf life of seeds, reducing the risk of microbial growth, and undesirable biochemical changes such as fermentation and early seed germination [25].

In a study conducted by Evaristo et al., 2010 [26] the approximate composition of Portuguese pine nuts was investigated by comparing 27 different Pinus spp populations. For the inspected 27 Portuguese populations, the average moisture content was found to be 5,9%. Compared to Turkish (5,1%) [12] and Spanish (5,04%) [27] pine nuts, this value was slightly above the usual level.

In a study by Venkatachalam and Sathe, 2006 [25] moisture, ash, protein and carbohydrate values in 100 g pine nuts were examined and the values were reported as 1,7%, 2,5%, 13,08%, and 1,82%, respectively.

3.2.Macro-Micro Elements And Vitamins

Nuts contain a wide variety of micro, macro elements and vitamins in sufficient quantities that have positive effects on health and contribute to the prevention of nutritional deficiency.

Pine nut is rich in nutrients such as fat-soluble vitamin E (alpha-tocopherol) (8.23%) and water-soluble vitamins B3(3,84), C (0,71), B1(0,51) and B5(0,49) [28,29].

In a study by Babich et al., 2017 [30] the main macro elements in pine nuts were reported as phosphorus (792,1 mg/100 g), potassium (600,0 mg/100 g of product) and magnesium (250,9 mg/100 g); microelements were reported as manganese (8,81 mg/100 g), iron (5,63 mg/100 g), and zinc (4,38 mg/100 g) [30].

In the study conducted by Şen et al., 2016 [19] the macro-micro elements of pine nuts were examined, and primarily potassium 733 mg/100 g, phosphorus 654 mg/100 g, calcium 16,03 mg/100 g, iron 10,83 mg/100 g, zinc 6,56 mg/100 g, copper 3,3 mg/100 g, manganese 5,83 mg/100 g and sodium 4,66 mg/100 g were reported.

Nergiz and Dönmez, 2004 [12] obtained similar results in their study with other studies (Table 2).

Table 2. Macro-micro element content of pine nuts [12].

Macro- micro element	**mg/100 g**
Na	11,70
K	713,00
Ca	13,80
Mg	325,00
Cu	1,50
Fe	10,20
P	512,00
Se	0,70
Mn	6,90

In addition, in a study investigating the chemical composition of Aleppo pine nuts (*Pinus halepensis Mill.*), macro-micro nutrients potassium (617,1 mg/100g), magnesium (330,3 mg/100g), calcium (116,7 mg/100g), phosphorus (56,8 mg/100g), sodium (6,96 mg/100g), iron (27,1 mg/100g), copper (2,25 mg/100g), zinc (13,49 mg/100g), and manganese (5,13 mg/100g) contents have been revealed [31].

In the analysis, it was seen that the element with the highest concentration was K, while the Na concentration was the most variable mineral.So much so that Özcan, 2006 [32] found the Na concentration to be higher (87,12 mg/100g) in his study in which he examined the composition of Turkish pine nuts. These results revealed low variation among pine nut populations [26].

From the perspective of human nutrition, pine nuts are a good source of P, Fe and Zn (1200, 10-15 and 12-15 mg, respectively) that can supply with the recommended daily intakes for adults [33] According to Özcan, 2006 [32] when compared to edible nuts such as peanuts, pistachios, walnuts, hazelnuts and almonds, pine nuts show the highest Zn, Cu and Fe content.

In a study conducted by Evaristo et al., 2010 [26] vitamins B1 (thiamine) (0,53mg / 100g) and B2 (riboflavin) (0,19mg/100g) were detected in significant amounts in pine nuts. These amounts represent approximately 35,3% and 11,9%, respectively, of the recommended dietary allowance (RDA) for an adult male, which recommends a daily intake of 1,6 mg of riboflavin and 1,5 mg of thiamine [34] Nergiz and Dönmez, 2004 [12] reported higher average vitamin content with only thiamine (1,50 mg/100g) significantly different. In the study, the amounts of Vitamins C, B1, and B2 were reported as 2,50, 150, 0,28 mg/100 g, respectively (Table 3).

Table 3. Vitamin content of pine nuts [12].

Vitamins	mg/100 g
Vitamin C	2,50
Thiamine (B1)	1,50
Riboflavin (B2)	0,28
Vitamin A	29,00
Vitamin B6	0,094
Vitamin C	0,80
Vitamin E	9,83
Vitamin K	53,90
Carotene beta	17,00
Lutein + zeaxanthin	9,00

3.3. Fatty Acid Composition

Nuts are a good source of fat and are considered good for health due to their high content of unsaturated fatty acids [36,37]. Although pine nuts have a high level of fat replacement, it is known that this oil prevents the rise of cholesterol and has a protective effect against cardiovascular diseases due to its high content of mono and polyunsaturated fatty acids [38,39].

According to Table 4, the total content of saturated fatty acids in the pine nut kernel is 9,53%, and the unsaturated fatty acid is 90,47% [30].

In th analyzed samples, linoleic acid (omega-3 fatty acids) has the highest value (43%), followed by oleic and linolenic acids with 24% and 21%, respectively. Palmitic (5.23%) and stearic (2.82%) acids predominate among saturated fatty acids. In a study by Şen et al., 2016 [19], the fatty acid composition of pine nuts was examined and they reported that unsaturated fatty acids constitute the majority of the total fatty acids (89,52%). It was determined that 85,4% of the unsaturated fatty acids are composed of linoleic and oleic acids, followed by palmitic, steraic, ecoatrinoic and linolenic fatty acids in terms of amount. In the study, it was determined that palmitic and steraic acids, which are among the saturated fatty acids, constitute 9,8% of the total fatty acid content. Similar results were also reported by Nergiz and Dönmez, 2004 [12].

In the study investigating the pine nuts by Venkatachalam and Sathe 2006 [25], it was determined that 24,1% of the fatty acid composition consisted of total saturated fatty acids, 27,55% of total monounsaturated fatty acids, and 48,35% of polyunsaturated fatty acids.

In another study investigating the fatty acid composition of Aleppo pine nut (*Pinus halepensis Mill.*), the oil rate was reported as 43,3%, while oleic (27,3%) and linoleic (48.8%) acids were the major unsaturated fatty acids in this oil, while palmitic acid was found to be a major saturated fatty acid. In addition, the presence of myristic, ricinoleic acid, palmitoleic, margaric, margaroleic, stearic, linoleic, arachidic, ecosadinoic, ecoatrinoic, behenic and lignoceric acids in peanuts was also detected [31].

Table 4. Fatty acid composition of pine nuts [30].

Fatty acid	Formula	g/100g (%)
	Saturated	
Myristic Acid	$C_{14:0}$	0,48
Palmitic Acid	$C_{16:0}$	5,23
Stearic Acid	$C_{18:0}$	2,82
Arachidonic Acid	$C_{20:0}$	1,00
Total		**9,53**
	Unsaturated	
PalmitoleicAcid	$C_{16:1}$	0,40
Oleic Acid	$C_{18:1}$	24,00
Linoleic Acid	$C_{18:2}$	43,00
Linoleic Acid	$C_{18:3}$	21,00
Gadoleic Acid	$C_{20:1}$	0,90
Exosadionic Acid	$C_{20:2}$	0,61
Exosatrionic Acid	$C_{20:3}$	1,20
Total		**90,47**

3.4. Proteins

Looking at the composition of pine nuts, it is seen that the second major component is protein. The average protein content of seeds is reported as 31,6% [12]. Similar results were reported by Farris, 1983 [40] and Ruggeri and Cappelloni et al., 1998 [41] Lanner, 1981 [42] stated in a study examining pine nut species that *P. Pinea* species had the highest protein content (34%) and its nutritional value was comparable to meat.

In a study investigating the chemical composition of Aleppo pine nut (*Pinus halepensis Mill*.), the protein was reported as 22,7% [31].

In a study by Evaristo et al., 2010 [26] the chemical composition of Portuguese pine nuts was investigated. In the study, it was reported that the protein ratio varied between 26,51% and 37,36%, and similar results were obtained with Turkish and Italian pine nuts. Canellas et al., 2000 [27] reported higher protein content for 10 Spanish pine nut populations (36,72%). Taken together, these results confirm that Turkish pine nut has the highest protein content among other pine nut species [12,43].

In the samples obtained from Pinus monophylla, Pinus quadrifolia, Pinus edulis and Pinus koraiensis, only 9,5, 11,0, 14,3, and 17,0–18,0 g crude protein contents were reported for 100 g, respectively [43].

Proteins in foods are broken down into amino acids after digestion. Amino acids are divided into two according to whether they are synthesized or not in the human body. Amino acids that cannot be synthesized in the body, known as essential amino acids, must be taken into the body with food [44].

Aspartic acid and glutamic acid, known as acidic amino acids, are the most abundant amino acids in nuts, and histidine amino acids are also found in high levels in all nuts [45]. Nuts are rich in arginine but poor in some essential amino acids (threonine, isoleucine, lysine, methionine, cysteine) [46].

Nuts have a low lysine/arginine ratio because they have a low lysine ratio. In addition, since nuts are protein-rich foods, their arginine and glycine contents are high [46].

In the study by Babich et al., 2017 [30] in which the potential of pine nuts in sports nutrition was examined, the approximate amino acid composition of pine nuts was revealed (Table 5).

Table 5. Amino acid composition of pine nuts [30].

Amino Acid Name	**g /100g (%) değeri**
Alanine	5,39
Arginine	15,43
Asparagine Acid	6,00
Valin	3,44
Histidine	2,81
Glycine	4,61
Glutamic Acid	11,80
Leucine + İsoleucine	15,73
Lysine	5,94
Methionine	1,64
Proline	5,50
Serin	6,77

3.5. Bioactive Substances

Pine nuts contain various bioactive substances and phenolic compounds [47] but their content is low compared to other tree nuts. The total amount of phenolic substances in pine nuts is reported as 58 mgGAE/100 mg by the USDA database, 2015 [48] while the Phenol-Explorer database [49] reports 68 mg GAE/100 mg. The Phenol-Explorer database [49] also reports the presence of matairesinol and secoisolariciresinol (0,2 and 0,4 mg/kg, respectively), indicating a low lignan content.

Taş and Gökmen, 2017 [50] investigated the phenolic components and antioxidant activities of some nuts in raw and roasted form in their study. According to the study, the amount of phenolic component of pine nuts in raw and roasted form was reported as 19,4 mg GAE/g and 9,79-21,5 mg GAE/g, respectively. While the antioxidant activity was 78,3 mg TE/g in the raw form, it was determined as 42,5–91,2 mg TE/g in the roasted form.

Nuts and seeds are considered among the richest sources of vegetable oils and vitamin E, the main fat-soluble vitamin. Esche et al., 2013 [51] analyzed 10 different tree nut oils and reported that the tocopherol content was highest in pine nut oil (0,33 mg/g).

In a study conducted by Lutz et al., 2016 [52] the chemical composition of pine nuts grown in 3 geographical regions in Chile was investigated. According to the study, mean vitamin E contents were found to be 59,0 ± 12,6 and 1071,1 ± 109,8 µg/kg for α- and γ-tocopherols, respectively.

In terms of antioxidant capacity, ORAC values observed in Chilean seeds have been reported as approximately 7,19 µmol TE/g [52, 53, 54] In addition, in the study of Lutz et al., 2016 [52] the vitamin C content observed in Chilean pine nuts was reported as 27,7 ± 1,4 mg/kg, although not exceptionally high.

In a study by Wu et al., 2004 [54] in which the lipophilic and hydrophilic antioxidant capacities of common foods were examined, among the commonly consumed tree nuts, it has been reported that pine nuts had the lowest total phenolic content (0,68 mg GAE/g) and have total antioxidant activity as 7,19 µmol TE /g.

Nasri et al., 2007 [55] analyzed seven pine nut populations from different European Mediterranean countries and reported very high levels of sterols (4376 mg/kg fat). The authors noted that β-sitosterol was the most abundant species (74%) in the entire P. pinea population (3208 ± 253 mg/kg fat), followed by campesterol (661 ± 32 mg/kg fat), Δ5-avenasterol (296 ± 67 mg/kg). kg fat) and Δ5,24-stigmastadienol (21 ± 5 mg/kg fat) species.

Lutz et al., 2016 [52] also examined other bioactive components in pine nuts in their study. The observed β-sitosterol content was an average of 18,18 ± 0,76 mg/kg of fat, meaning that the β-sitosterol content was more than 60% higher than stigmasterol in pine nuts grown in the three Chilean geographies. The predominance of β-sitosterol, which accounts for more than 60% of total free sterols/stanols in other edible nuts such as almonds, hazelnuts and walnuts, has been consistently observed in other studies in pine nuts [51, 56].

In-shell pine nuts do not contain phenolic compounds in comparable amounts to other tree nuts such as walnuts and hazelnuts [57] In the study of Lutz et al., 2016 [52] the total amount of phenolic components (TPC) observed in pine nuts was determined at the level of 0,34 ± 0,05 mg GAE/g.

Senter et al., 1983 [58] studied the total phenolic acid content in defatted Pinus edulis pine nut pulp. As a result of this study, it was determined that the predominant phenolic acid was caffeic acid and the total amount of phenolics was 0,137 mg GAE /g per 100 g of defatted pine nuts.

In a study by Cheikh et al., 2006 [31] it was reported that the polyphenol content in the oil of pine nut (*Pinus halepensis*) was 0,186 mg GAE/100 g. In another study examining the total phenolics in pine nuts purchased from Austria and Greece, Kornsteiner et al., 2006 [53] reported that the phenolic content was low (32 mg GAE/100 g).

4. The Effect Of Pıne Nuts On Health

Health science associations such as the US Food and Drug Administration (Food and Drug Administration [FDA], 2003) and the Canadian Cardiovascular Society [59] recommend regular consumption of peanuts in the context of a healthy diet to prevent overall cardiovascular disease risk.

The heart-protective components of pine nuts include unsaturated fatty acids, phytosterols, various tocopherols (α-, γ-, and δ tocopherols), and squalene [60,61,62].

Most tree nut oils show a high content of monounsaturated fatty acids, primarily oleic acid (18:1n-9), while pine nut oil is a more abundant polyunsaturated (PUFA), particularly linoleic acid (18:2n-6) acid profile [12,25,26,55,63,64,65].

Vanhanen et al., 2017 [66] examined the fatty acid composition of five pine nut cultivars grown in New Zealand in a study they conducted. Compared to common tree nuts, New Zealand pine nuts have been found to be an excellent source of α-linolenic acid. It is well known that this fatty acid has a number of cardioprotective effects such as anti-thrombotic, anti-inflammatory and anti-arrhythmic properties [64].

Pine nut oil is also a good source of phytosterols, one of the components of plant cell membranes, which inhibit intestinal absorption of cholesterol and thus have a lowering effect on total plasma cholesterol and LDL levels [67,68,69]. These compounds have anti-inflammatory, anti-atherogenic, anti-cancer and antioxidant effects [70,71].

In regulating blood pressure; K, Ca and Mg are important minerals and pine nut oil, which is a good source in this sense, has also been studied for its effects on lowering blood pressure and modulating immune functions [72,73].

In an early 1994 study, pine nut oil containing approximately 18% pinolenic acid was compared with linseed, safflower, and evening primrose oils for its effects on PUFA metabolism, eicosanoid biosynthesis, and blood pressure in Sprague-Dawley rats [72]. After 5 weeks of receiving the treatment diet containing 10% by weight of the tested oils, pine nut oil (*P. koraiensis*) was observed to reduce the increase in systolic blood pressure of spontaneously hypertensive rats. This leaning continued until the end of the study at week 8. In this study, a significant difference was observed between diets supplemented with pine nut oil and evening primrose oil, but not with safflower oil [72]. Thus, it has been reported that pinolenic acid may not prevent the conversion of linoleic acid to arachidonic acid.

In another study, Bakthin et al., 2006 [74] stated that taking 17.5 g of Siberian pine nut oil daily can improve systolic blood pressure in humans [74].

Several studies have examined the possible effects of pine nut oil on immune functions due to its unique fatty acids [73,75]. In 2004, another Mouse-feeding study evaluated the effects of pine nut oil on the intestinal immune system and macrophage in mice. Peyer patch cells were isolated from the small intestine of C3H/He mice fed a diet containing 5% Korean pine nut oil for 20 days and used in an in vitro immune response study. These cells showed a 1,5-fold increase in immune system modulation activity compared to cells from control mice fed the corn oil diet. Furthermore, a diet fed ICR mice with 5% pine seed oil for 20 days was observed to increase the stimulation of macrophages, although statistically insignificant [73].

In another study in which brown Norway rats were fed a diet containing 10% pine seed oil, it

was observed that spleen CD4 + T-lymphocytes and spleen immunoglobulins IgG and IgE were increased compared to control of safflower oil [75].

Dietary fiber is one of the basic components of human nutrition because it gives a feeling of satiety. Nuts are rich in fiber, which regulates the digestive system. Dietary fiber is divided into two soluble and insoluble. While insoluble fiber absorbs water and prevents constipation by making the stool soft, soluble fiber has functions such as regulating blood sugar, lowering cholesterol levels, and protecting against cardiovascular diseases.

In a study, soluble and insoluble fiber contents of oilseeds were investigated and 1,4% water-soluble pulp and 5,8% water-insoluble pulp contents of pine nuts were reported [76].

5. Conclusion

As it can be understood from the summary information given, it is observed that pine nuts have important and beneficial effects on human nutrition and health.

- Pine nuts are rich in a wide variety of micro, and macro elements and vitamins in sufficient quantities that can have a positive effect on health.
- Pine nuts are a rich source of oil and protein. Pine nuts, which have an important value in terms of unsaturated fatty acids, have anti-thrombotic, anti-inflammatory, anti-arrhythmic, and anti-cancer effects due to the mono and multiple fatty acids they contain.
- Pine nuts contain bioactive components such as phytosterols and tocopherols, which have functions that reduce the risk of cardiovascular disease, lower cholesterol, strengthen immunity and regulate blood pressure. It also contains a high amount of dietary fiber, which helps regulate the digestive system and blood sugar.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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