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Vitamin Contents of Some Pistachio Cultivars

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Abstract
Pistachio is an important nutrient in human diet with its rich content of vitamins. This study aimed to investigate vitamin contents of some pistachio cultivars (Halebi, Kırmızı, Ohadi, Siirt and Uzun) grown in the ecology of Gaziantep-Turkey. Vitamin contents of pistachio cultivars examined ranged between 15.21-26.25µg $100g^{-1}$ for vitamin A, 1.66-3.47 mg $100g^{-1}$ for vitamin E (α-tocopherol), 0.58-0.74 mg $100g^{-1}$ for vitamin B1 (tiamin), 0.16-0.18 mg $100g^{-1}$ for vitamin B2 (riboflavin), 1.25-1.39 mg $100g^{-1}$ for vitamin B3 (niacin), 1.33-1.55 mg $100g^{-1}$ for vitamin B6 (pyridoxine), 20.33-22.85 µg $100g^{-1}$ for biotin, 40.50-68.00 µg $100g^{-1}$ for vitamin B9 (folic acid) and 0.77-5.04 mg $100g^{-1}$ for vitamin C (ascorbic acid).
Keywords: *Pistacia vera*, vitamin

Bazı Antepfıstığı Çeşitlerinin Vitamin İçerikleri

Özet
Antepfıstığı meyvesi, yapısında bulundurduğu vitaminler açısından insan beslenmesinde önemli bir kaynak niteliğindedir. Bu çalışmada, Gaziantep ekolojisinde yetiştirilen Halebi, Kırmızı, Ohadi, Siirt ve Uzun antepfıstığı çeşitlerinin vitamin içerikleri araştırılmıştır. Birbirini izleyen yıllarda incelenen antepfıstığı çeşitlerinde belirlenen vitaminlerin miktarları 15.21-26.25µg $100g^{-1}$ A vitamini, 1.66-3.47 mg $100g^{-1}$ E vitamini (α-tokoferol), 0.58-0.74 mg $100g^{-1}$ B1 vitamini (tiamin), 0.16-0.18 mg $100g^{-1}$ B2 vitamini (riboflavin), 1.25-1.39 mg 100g-1 B3 vitamini (niasin), 1.33-1.55 mg $100g^{-1}$ B6 vitamini (pyridoksin), 20.33-22.85 µg $100g^{-1}$ biotin, 40.50-68.00 µg $100g^{-1}$ B9 vitamini (folik asit) ve 0.77-5.04 mg $100g^{-1}$ C vitamini (askorbik asit) şeklindedir.
Anahtar kelimeler: *Pistacia vera*, vitamin

INTRODUCTION

Pistachio is one of the nuts with a high nutrient value due to its rich content of proteins, vitamins, minerals, fat and fatty acids as well as antioxidants [1]. Pistachio has an energy value of 567 kcal $100g^{-1}$ and it is a significant source of carbohydrate (29.38 g $100g^{-1}$), fat (53.7 g $100g^{-1}$), protein (20.95 g $100g^{-1}$) and dietary fiber (9.9 g $100g^{-1}$) [2]. 28 g of roasted pistachio supplies 13% and 12% of recommended daily intake of protein and dietary fiber, respectively [3]. Furthermore, it is a richer source of proteins and minerals compared to walnut, hazelnut and beef. Nuts and particularly pistachios are characterized by high proportion of unsaturated (especially oleic acid) to saturated fatty acids despite high fat content (more than 50% of dry weight). A growing interest has been posed into antioxidant vitamins based on the evidence that biochemical by-products and stress-induced free radicals are responsible for the development of numerous diseases. Pistachio is one of the most healthy nuts with its rich content of antioxidant (C and E), fat-soluble (A, E, K) and water-soluble (B1, B2, B3, B5, B6, biotin, B9, C) vitamins. The studies on the benefits of daily nut consumption particularly explore the effects of daily nut intake on blood lipids, metabolic health and cardioprotection [4, 5]. Despite numerous studies have been conducted on fat, fatty acid, protein and mineral contents of pistachios, other nutrition compounds such as antioxidants and vitamins also have been become important especially in recent years. In this sense to know the vitamin contents of species is significant issue. In this study, vitamin contents of some pistachio cultivars have been explored in pistachio which is known as rich species in terms of especially antioxidant vitamins.

Vitamins, as one component of micronutrients, are important organic compounds for sustaining health and life which are crucial for growth and development, maintaining functions of nervous and digestive systems, efficiency of food utilization and supporting immune system [6]. Besides their important functions on metabolism, they are also essential for normal cell function [7,8]. Due to its strong antioxidant vitamin (C and E) property as well as rich content of fat-soluble (A, E, K) and water-soluble (B1, B2, B3, B5, B6, biotin, B9, C) vitamins, pistachio is a good source of vitamins for human nutrition [3, 9, 10].

Pistachio has been suggested as a rich source of vitamin A (553 IU $100g^{-1}$) which plays role in a variety of functions throughout the body, such as immune function against infections, vision, epithelial tissue maintenance, growth and development as well as embryonic development and reproduction [11]. It has been reported that vitamin A content of pistachio was high as 415 IU $100g^{-1}$ [2] and 11.90 µg $42.5g^{-1}$ [9]. Pistachio is a good source of vitamin E, which is suggested to protect against cancer and arteriosclerosis in people with diabetes. One of the theories for heart protection argues that tocopherols prevent LDL (bad cholesterol) oxidation which is suggested as the key role in atherogenic process [12]. Antioxidant vitamin E has been reported to slow down the course of Alzheimer's disease, strengthen immune system, contribute to cell maintanence and renewal, ward off coronary heart disease and cancer, prevent anemia by maintaining the stability of the red blood cell membranes

and speed up cleaning of microorganisms from the blood after infections [13]. The highest contents of vitamin E in hazelnut (26.1 and 10.91 mg $100g^{-1}$) and almond (24.2 and 11.22 mg $100g^{-1}$) and a much lower content of vitamin E (5.2 mg $100g^{-1}$) in pistachio [14,9]. It has been suggested that total tocopherol content in the fats of pecan, Brazil nut, pine nut, cashew nut and pistachio range between 60.8-291 mg g^{-1} and total tocopherol content of pistachio is 291 mg g^{-1}, of which 275.4 mg g^{-1} is γ-tocopherol and 15.6 mg g^{-1} is α-tocopherol [15]. Average total tocopherol and tocotrienol content of *Pistacia terebinthus* fruits was determined as 465.7 mg kg^{-1} [16]. Kornsteiner et al. [17] detected that β and γ tocopherols are the most predominant tocopherols in seven nut species and the order of decreasing β and γ tocopherol contents was pistachio> walnut>pecan> Brazil nut>pine nut>peanut>cashew nut. The highest α-tocopherol content (31.4 mg $100g^{-1}$) was measured in hazelnut while pistachio has the lowest content (15.6±1.2 µg g^{-1} oil) among nuts. The highest β and γ tocopherol contents of pistachio were 29.3 mg $100g^{-1}$ while the highest content of γ-tocopherol was in walnut (300.5±31.0 µg g^{-1} oil) then in pistachio (275.4±19.8 µg g^{-1} oil) [17; 10]. Vitamin K plays a major role in healthy blood clotting and its deficiency leads to some liver diseases manifested as fat absorption abnormalities. The nut species except cashew nut (34.8 µg $100g^{-1}$) and pine nut (53.9 µg $100g^{-1}$) were found to have insignificant contents of vitamin K, which was measured as 13.2 µg $100g^{-1}$ in pistachio [18, 2]. Tiamin (vitamin B1) helps with regulation of blood circulation, digestion by improving hydrochloric acid production, blood formation and metabolization of carbohydrates [19]. It helps to calm down the nervous system and maintain normal heart function [11]. Lack of vitamin B1 causes beriberi disease, polyneuritic heart disorders and disorders in water-salt metabolism and digestive system. Lactoflavin or riboflavin (vitamin B2) regulates oxidation processes in cells and helps to maintain normal heart rhytm and respiratory functions. It is needed to process fats and normalize endogenous synthesis and promotes biological effect of tiamin. Vitamin B2 increases sensitivity of liver cells to insulin and promotes insulin release by stimulating peptic glands [20]. Deficiency of vitamin B2 leads to photophobia, blurred vision, burning of the eyes, vascularization in cornea, cataract, oily skin texture and eczema in testicles, mouth, nose and lips [19]. Niacin (vitamin B3) helps break down of carbohydrates and promotes the health of central nervous system, regulates nicotinic acid nitrogen metabolism, blood cholesterol levels, synthesis of fatty acids and processes involved in formation of red blood cells in the bone marrow [20]. Pistachio (0.67 mg $100g^{-1}$) was detected to be the highest in vitamin B1, followed by hazelnut (0.46 mg $100g^{-1}$), walnut (0.33 mg $100g^{-1}$) and almond (0.24 mg $100g^{-1}$) [14]. Pantothenic acid (vitamin B5) deficiency causes growth retardation, skin problems and nervous system disorders, interferes with mineral and water metabolism in the body. Lack of vitamin B5 also causes fatigue and weakness, nausea, vomiting, paresthesia, muscle cramps followed by adrenocortial failure and neuromuscular degeneration [19]. Vitamin B6 plays an important role in amino acid metabolism, helps to calm down the nervous system and promotes the health of heart. Lack of vitamin B6 cause disorders in trypthophane metabolism and nervous system as well as skin problems [11]. Folic acid or folate (vitamin B9) plays a key role in one-carbon metabolism and is needed to carry one-carbon groups for methylation of essential biological substances including phospholipids, proteins, DNA and neurotransmitters and for synthesis of purine and thymine [21]. Folic acid deficiency leads to megaloblastic (macrocytic) anemia particularly in pregnant women which is associated with lack of adequate healthy red blood cells.

Although the exact mechanism is unknown, low dietary intake of folic acid may increase the risk of developing colon, stomach and uterus cancers and also leads to cardiovascular diseases and neural tube defects (NTD) such as anencephaly and sipina bifida resulted by elevated serum homocysteine levels [22]. Hazelnut has the highest folate content (113 µg $100g^{-1}$) among nuts while pistachio has a folate content of 51 µg $100g^{-1}$ [10]. 28 g of pistachio has been reported to deliver 37% of recommended daily intake of vitamin B6, 22% of recommended daily intake of vitamin B1, 12% of recommended daily intake of vitamin B3, 8% of recommended daily intake of vitamin E, 4% of recommended daily intakes of vitamin B2 and folic acid and 3% of recommended daily intake of vitamin B5 [3]. Vitamin C (ascorbic acid) has numerous functions in human body. The most important of those is scavenging free radicals produced as a result of oxygen metabolism. Vitamin C contents were 6.38 mg $100g^{-1}$, 2.68 mg $100g^{-1}$ and 2.13 mg $100g^{-1}$ respectively in European nut, hazelnut and pistachio [9] and 3 mg $100g^{-1}$ in pistachio [2].

MATERIAL AND METHODS

Halebi, Kırmızı, Ohadi, Siirt and Uzun pistachio cultivars are used as study materials which are intensively grown in Turkey. Pistachio samples were taken in two consecutive harvest years from healthy, well-developed and mature pistachio trees grown under non-irrigated, dry conditions in Gaziantep region of Turkey. Rootstocks on which pistachios grafted is *P. vera*. After harvest, the samples were dried down in the sun until the moisture content of the sample was reduced to 3-5%. Analyses were performed on randomly selected samples for each cultivar and repeated for each experiment year. Fat-soluble vitamins A and E were detected according to Anonymous [23, 24], water-soluble vitamins B1 (tiamin) and B2 (riboflavin) were detected according to Reyes and Subryan [25], vitamin B3 (niacin) was detected according to Ndaw et al. [26], vitamin B6 (pyridoxine) was detected according to Kall [27], vitamin B9 (folic acid) was detected according to Vahteristo et al. [28], biotin was detected according to Anonymous [29] and vitamin C (ascorbic acid) was detected according to Gökmen et al. [30]. Vitamins were quantified with HPLC and GC equipment.

RESULTS AND DISCUSSION

Vitamin A contents of pistachio cultivars ranged between 15.21±0.610 µg $100g^{-1}$ and 26.25±0.610 µg $100g^{-1}$. The highest vitamin A content was measured in Halebi (26.25±0.610 µg $100g^{-1}$) followed by Uzun (24.33±0.195 µg $100g^{-1}$), Kırmızı (18.28±0.145 µg $100g^{-1}$), Ohadi (16.35±0.225 µg $100g^{-1}$) and Siirt (15.21±0.610 µg $100g^{-1}$). Differences between groups in vitamin A content were found to be statistically significant. The differences between vitamin A contents of Halebi and Uzun, as the highest in vitamin A, and those of Kırmızı, Ohadi and Siirt were found to be statistically significant. Siirt had a significantly lower content of vitamin A compared to all cultivars except Ohadi (Figure 1). Vitamin E (α-tocopherol)

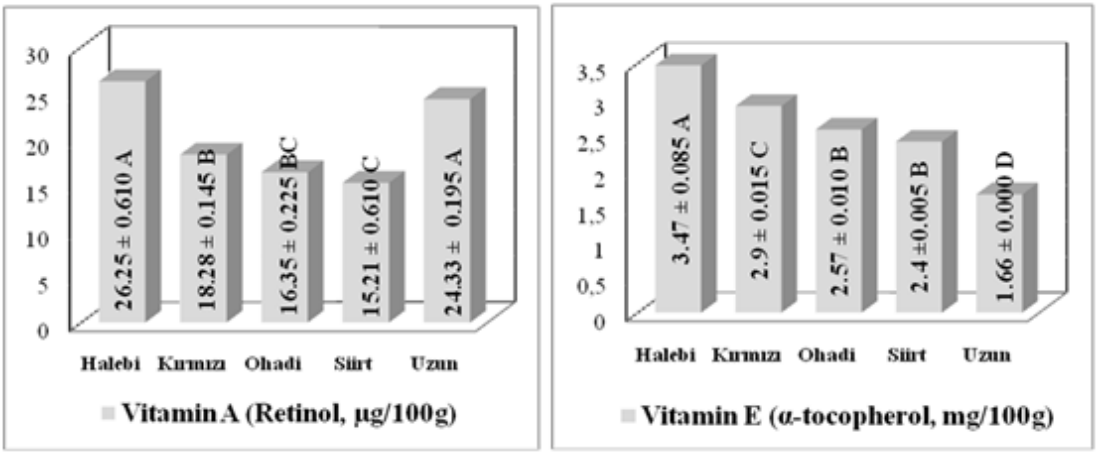

Figure1. Fat soluble Vitamin A and E contents (mg $100g^{-1}$) of the pistachio cultivars. Averages with different letters denote statistically significant differences ($P<0.01$).

contents of pistachio cultivars ranged between 1.66±0.000 mg $100g^{-1}$ and 3.47±0.085 mg $100g^{-1}$. The highest vitamin E content was measured in Halebi (3.47±0.085 mg $100g^{-1}$) followed by Kırmızı (2.90±0.015 mg $100g^{-1}$), Ohadi (2.57±0.010 mg $100g^{-1}$), Siirt (2.40±0.005 mg $100g^{-1}$) and Uzun (1.66±0.000 mg $100g^{-1}$). While the differences between Siirt and Ohadi in vitamin E contents were statistically insignificant, the differences between these two cultivars and Halebi, Kırmızı and Uzun in vitamin E contents were found to be statistically significant (Figure 1).

When water soluble vitamin contents of pistachio cultivars ranged between 0.58±0.000 mg $100g^{-1}$ and 0.74±0.005 mg $100g^{-1}$ vitamin B1 (tiamin), 0.16±0.000 mg $100g^{-1}$ and 0.18±0.000 mg $100g^{-1}$ vitamin B2 (riboflavin), 1.25±0.025 mg $100g^{-1}$ and 1.39±0.015 mg $100g^{-1}$ vitamin B3 (niacin), 1.33±0.030 mg $100g^{-1}$ and 1.55±0.010 mg $100g^{-1}$ vitamin B6 (pyridoxine), 20.33±0.075 µg $100g^{-1}$ and 22.85±0.050 µg $100g^{-1}$ biotin, 40.50±3.50 µg $100g^{-1}$ and 68.00±6.00 µg $100g^{-1}$ vitamin B9 (folic acid), 0.77±0.010 mg $100g^{-1}$ and 5.04±0.145 mg $100g^{-1}$ vitamin C (ascorbic acid) respectively (Figure 2).

The highest vitamin B1 content was measured in Siirt (0.74±0.005 mg $100g^{-1}$) followed by Uzun (0.73±0.005 mg $100g^{-1}$), Ohadi (0.70±0.000 mg $100g^{-1}$), Halebi (0.63±0.000 mg $100g^{-1}$) and Kırmızı (0.58±0.000 mg $100g^{-1}$). Siirt and Uzun had significantly higher contents of vitamin B1 compared to those of Ohadi, Halebi and Kırmızı (Figure 2). The highest vitamin B2 content was measured in Ohadi (0.18±0.000 mg $100g^{-1}$) followed by Uzun and Kırmızı (0.17±0.000 mg $100g^{-1}$), Siirt and Halebi (0.16±0.000 mg $100g^{-1}$). The differences between cultivars in vitamin B2 contents were not statistically significant (Figure 2).

The highest vitamin B3 content was measured in Ohadi (1.39±0.015 mg $100g^{-1}$) followed by Kırmızı (1.36±0.000 mg $100g^{-1}$), Siirt (1.30±0.015 mg $100g^{-1}$), Halebi (1.26±0.005 mg $100g^{-1}$) and Uzun (1.25±0.025 mg $100g^{-1}$). The differences between Siirt, Uzun and Halebi in vitamin B3 contents were not statistically significant. However, Ohadi and Kırmızı had significantly higher contents of vitamin B3 compared to those of other cultivars (Figure 2).

The highest vitamin B6 content was measured in Uzun (1.55±0.010 mg $100g^{-1}$) followed by Kırmızı (1.44±0.000 mg $100g^{-1}$), Siirt (1.40±0.035 mg $100g^{-1}$), Halebi (1.36±0.015 mg $100g^{-1}$) and Ohadi (1.33±0.030 mg $100g^{-1}$). Uzun had a significantly higher content of vitamin B6 compared to those of Siirt, Halebi and Ohadi. The differences between Kırmızı and Uzun in vitamin B6 contents were not statistically significant (Figure 2).

The highest biotin content was measured in Ohadi (22.85±0.050 µg $100g^{-1}$) followed by Uzun (21.78±0.525 µg $100g^{-1}$), Kırmızı (20.78±0.075 µg $100g^{-1}$), Siirt (20.40±0.100 µg $100g^{-1}$) and Halebi (20.33±0.075 µg $100g^{-1}$). Uzun and Ohadi had significantly higher contents of biotin compared to those of Siirt, Halebi and Kırmızı (Figure 2).

The highest vitamin B9 (folic acid) content was measured in Ohadi (68.00±6.00 µg $100g^{-1}$) followed by Kırmızı (58.50±6.50 µg $100g^{-1}$), Halebi (56.00±6.00 µg $100g^{-1}$), Siirt (45.00±4.00 µg $100g^{-1}$) and Uzun (40.50±3.50 µg $100g^{-1}$). The differences between other cultivars in folic acid were not statistically significant (Figure 2).

The highest vitamin C content was measured in Kırmızı (5.04±0.145 mg $100g^{-1}$) followed by Halebi (3.22±0.000 mg $100g^{-1}$), Uzun (1.94±0.125 mg $100g^{-1}$), Siirt (1.28±0.085 mg $100g^{-1}$) and Ohadi (0.77±0.010 mg $100g^{-1}$). The differences between Siirt and Ohadi in vitamin C contents were statistically insignificant. These two cultivars had significantly lower contents of vitamin C compared to those of Kırmızı, Halebi and Uzun. The differences between other cultivars in vitamin C contents were also statistically significant (Figure 2).

The findings of the present study on fat-soluble vitamins are mostly in agreement with those of other researchers [31, 14, 9]. In the studies of different researchers, α-tocopherol were found as 7.3 mg $100g^{-1}$, 15.6 mg $100g^{-1}$ and 0.51 mg $100g^{-1}$ respectively [17, 15, 32]. In the current study, vitamin E (α-tocopherol) contents ranged between 1.66±0.000 mg $100g^{-1}$ and 3.47±0.085 mg $100g^{-1}$. Water soluble vitamin contents of pistachio were measured as 1.28 mg $100g^{-1}$, 0.7 mg $100g^{-1}$ and 0.67 mg $100g^{-1}$ vitamin B1 [33, 31, 14], 1.50 mg $100g^{-1}$ and 1.40 mg $100g^{-1}$ vitamin B3, 0.06 mg $100g^{-1}$, 58 µg $100g^{-1}$ and 51 µg $100g^{-1}$ folic acid [31, 14, 10]. Other findings are in accord with those of the present study. Vitamin C (ascorbic acid) contents ranged between 0.77±0.010 mg $100g^{-1}$ and 5.04±0.145 mg $100g^{-1}$ in this study and in agreement with the findings of 3.48±0.23 mg $100g^{-1}$ and 2.13 mg $100g^{-1}$ respectively [32, 9]. Several studies are present the content of pistachio nutrition compounds such as fat and fatty acids, minerals, fenolic compounds, flavonoids and

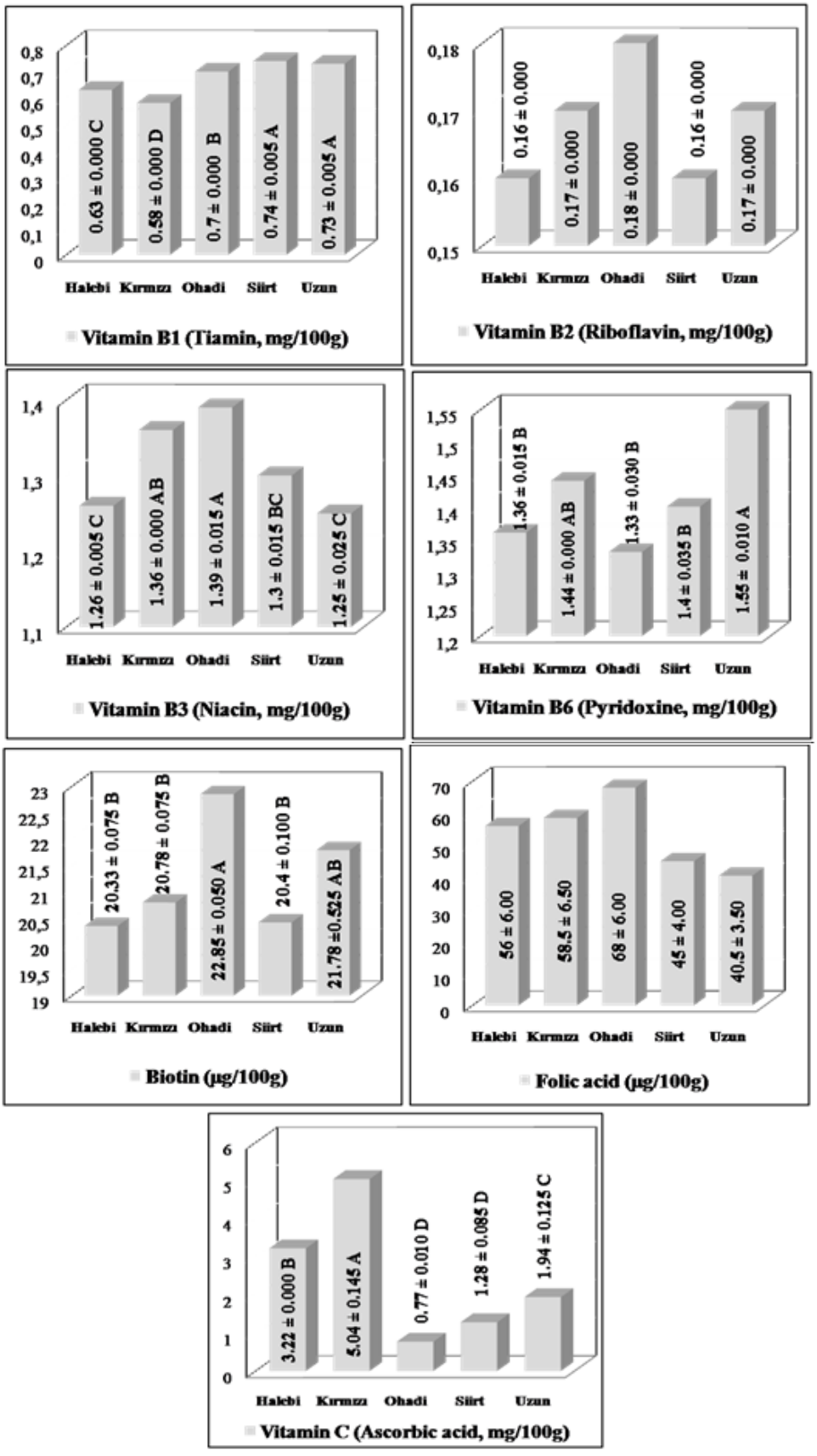

Figure 2. Water soluble vitamin B1, B2, B3,B6, Biotin and C contents (mg $100g^{-1}$) of the pistachio cultivars. Averages with different letters denote statistically significant differences ($P<0.01$).

phytosterols and the factors associated with these compounds [34, 35, 36, 37, 38]. However, studies about vitamin contents of pistachio are much more limited. Regarding the significant effects of antioxidants on human health, studies have been concentrated on especially antioxidant vitamins in pistachio as a rich source of these compounds. The effects of factors such as genotype, environmental conditions, roasting process on antioxidants, fenolic compounds and flavonoid contents of plants have been investigated in these studies [32, 38]. Vitamin content in fruits is basically related with the variety in addition to postharvest processes such as drying, roasting and different storage conditions that affect nutritional properties and some vitamins with antioxidant activities [39]. Consistent with these studies, in the present study, no significant difference was observed between two years in terms of different vitamin contents of pistachio fruits at the same variety harvested at two consecutive years and vitamin contents showed similar values according to variety at both years. Knowing that compounds like antioxidants and fenolics are affected from many factors such as heat and moisture, the effects of especially postharvest processes on vitamin composition in fruit species such as pistachio rich in these compounds is required. Therefore, determining vitamin content in pistachio varieties has great importance for future studies.

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