

## Evaluation of Protein, Fat and Fatty Acids Content of the Pistachio (*pistacia vera L.*) Cultivars of Damghan, Iran

Abdoshahi A.<sup>1,3</sup>, Mortazavi S.A.<sup>2,3</sup>, Shabani A.A.<sup>4</sup>, Elhamirad A.H.<sup>3</sup>, Taheri M.<sup>5</sup>

<sup>1</sup> Health and Medical network of Damghan, Semnan University of Medical Sciences, damghan, Iran.

<sup>2</sup> Department of Food Science and Technology, Ferdowsi University of Mashhad, Mashhad, Iran

<sup>3</sup> Department of Food Science and Technology, Sabzevar Branch, Islamic Azad University, Sabzevar, Iran

<sup>4</sup> Biotechnology center of Semnan University of Medical Sciences, Semnan, Iran

<sup>5</sup> Damghan Branch, Islamic Azad University, Damghan, Iran

**Abstract:** Pistachio nut has high nutritional value. The fat and protein are the common part of pistachio. Major part (about 88%) of the fat content of pistachio includes unsaturated fatty acids. Unsaturated fatty acids are known to have positive effects on human health like preventing to heart diseases. This research has evaluated protein, fat and fatty acids content of some commercial pistachio cultivars of Damghan, Iran namely Akbari, Kaleghoui, Khanjari, Abasali and Shahpasand. The results showed protein and fat contents in studied pistachio cultivars varied from 16.2654 % (Shahpasand) – 20.7025 % (Abasali) to 52.4840 % (Shahpasand) – 60.6470% (Akbari), respectively. Regarding of protein and fat there have been significant differences between cultivars. The composition of fatty acids were determined as myristic (0.0810- 0.1080%), palmitic (10.2275- 11.10750%), stearic (1.1010- 1.2700%), arashidic (0.3855- 0.6300%), palmitoleic (0.8175- 1.0180%), oleic (48.9615- 55.2435%), linoleic (30.4820- 36.8840%), linolenic (0.3590- 0.8405%). Oleic acid has been found as the most common monounsaturated fatty acid. Linoleic acid has the highest percentage among polyunsaturated fatty acids. There have been significant differences among pistachio cultivars regarding unsaturated fatty acids. The ratio of unsaturated fatty acids to saturated ones has changed between 6.7- 7.4

**Keywords:** Fat; Fatty Acid Composition; Pistachio Cultivar; Protein

### INTRODUCTION

Iran is first in the rank for worldwide production of pistachio, which has a wide population of wild pistachio and several pistachio cultivars. In 2011, more than 220,000 tons pistachio nuts were produced in Iran (Agriculture ministry of Iran, 2011). Pistachio nuts are known to have a high nutritional value. The kernels are a good source of, protein, fat and fatty acids especially essential unsaturated fatty acids. Pistachios also serve as a good source of vitamins and minerals such as vitamin A, E, B1, B6 and folat, iron, phosphorus and zinc [19].

Pistachio contains 50-70 % fat and major part of that are unsaturated fatty acids. About 80 % of unsaturated fatty acids are oleic acid and linoleic acid. Unsaturated fatty acids are known to have positive effects on human health like preventing accumulation of cholesterol and arteriosclerosis. Nut consumption decreases the risk of cardiovascular heart disease, which may be partly explained by the cholesterol lowering effect of unsaturated fatty acids. Essential fatty acids are important because they are the only substance synthesizing prostaglandin, which prevent erythrosine from accumulating in blood (Kayahan, 1978).

**Corresponding Author:** Abdoshahi A., Health and Medical network of Damghan, Semnan University of Medical Sciences, Damghan, Iran Email: abdosshahianna@yahoo.com

Satil [29] found that the geographical location of pistachio trees has an effect on the fatty acid content of its nuts. Oilseeds have different commercial value because of their fatty acid composition. In this regard, pistachio cultivars from different geographic origin have been studied [24, 7, 2, 3, 15]. Knowing the fatty acid composition of pistachio cultivars has benefits to evaluate the nutritional and commercial quality of them and so it could well apply in cultivar selection in agricultural program.

In addition, it provides the good information for pistachio oil production. There are number of studies focused on fat and fatty acid content of Iranian pistachio cultivars [17, 15, 23]. However, all of them were studied pistachio cultivars from Kerman and Rafsanjan regions in Iran. Damghan is one of the old pistachio planting regions in Iran. About 30000 ton pistachio nuts had been produced in this region in 2011 (Agriculture office of Damghan, 2011). Domestic pistachio cultivars of Damghan have not been evaluated in nutritional aspects. Different results among the same cultivars grown in similar ecological conditions showed that there are upper and lower limits of fat and fatty acid content in pistachio [24].

In this paper, protein, fat and fatty acid contents of five domestic pistachio cultivars (Akbari, Kaleghoui, Khanjari, Abasali and Shahpasand) were assessed from Damghan region in Iran. The results compared with the result of other studies on different pistachio cultivars in the world.

## **MATERIALS AND METHODS**

### *Chemicals and samples*

All chemicals were supplied by Merck Co (Darmstadt, Germany). The study covered five standard cultivars officially registered in Damghan, Iran. These included Akbari, Kaleghouchi,

Khanjari, Abasali and Shahpasand that were obtained from Pistachio Research Institute of Damghan, Iran (in September 2011).

### *Sample preparation*

Fruit samples of pistachio after manual peeling, were dried at 70°C using oven (Shellab, CE5F-2, USA). The dry pistachio kernels were milled and passed through a sieve with mesh size of 16 and dried at 65 °C to a constant weight. They were kept within a sealed bag in a refrigerator (1-2°C) until they were used.

### *Protein content*

Protein content of samples was measured according to Kjeldahl method (ISIRI, No 2863, 1987). The coefficient used to convert nitrogen percentage to crude protein percentage is 5.50 [24].

### *Total fat content and fatty acid composition*

Fat percentage has been determined by Soxhlet method using n-Hexan as solvent (ISIRI, No 2862, 1987). An automated soxhlet set (Extraction system B- 811, Buchi Switzerland) were applied to extraction of pistachio oil. The solvent/oil was separated using a rotary evaporator (Buchi, R-210/215, Switzerland) with vacuum control and thermostatic bath (Buchi, V-700, Switzerland). Extracted oil was used for fatty acid analysis.

The fatty acid composition of the pistachio oil was determined by gas chromatography–flame ionization detector (GC-FID) according the Ce1f-96 Method of AOCS (2002). The oil samples were converted to methyl esters by vigorous shaking of a solution of oil in *n*-hexan (7ml) with 2 ml methanolic potassium hydroxide solution. The tube of solution was placed in a water bath (55 °C ) for 20 min and was shaken each 5 minutes. After decantation during final 5 min, the 1  $\mu$ l of upper

*Statistical analysis*

layer was injected on the GC-FID (6890N, Agilent, US) equipped with BPX70 capillary column (120m × 0.25 mm × 0.25 μm). The analysis followed the conditions: initial temperature of 160 °C and final temperature of 220 °C , with heating rate of 18 °C /min, detector temperature of 250 °C, injector temperature of 230 °C, nitrogen as carrier gas at pressure of 42.12 psi.

The results were statistically evaluated by a one-way ANOVA analysis on completely randomized design by SPSS program version 17.0.1. The significant difference at level of 5% (p<0.05) was analyzed by the Duncan test.

**RESULTS AND DISCUSSIONS**

*Protein and fat content*

The fat and protein content of studied pistachio cultivars has been shown in Table 1.

Table 1. Fat and protein ratios determined in the pistachio cultivars studied

Cultivar	Fat (%)	Protein (%)
Akbari	60.647 <sup>de</sup>	19.665 <sup>cd</sup>
Kaleghochi	56.350 <sup>b</sup>	18.509 <sup>bc</sup>
Khanjari	59.703 <sup>cd</sup>	17.358 <sup>ab</sup>
Abasali	57.772 <sup>c</sup>	20.703 <sup>d</sup>
Shahpasand	52.482 <sup>a</sup>	16.265 <sup>a</sup>

\*Same letter indicates no significantly difference at p < 0.05.

Protein content of pistachio cultivars varied from 16.265% (Shahpasand) to 20.703% (Abasali). The protein content of pistachio cultivars is significantly different (p<0.05). Kamangar [17] had determined the protein content in Ohadi (Iranian cultivar) as 17.08 % whereas Okay [24] reported this content for Ohadi as 22.057 %. The protein content in Turkish cultivars studied by Okay [24] was in Uzun (19.583 %), Kirmizi (22.550%), Halebi (25.063%), and Siirt (24.607%). Our results about protein content are lower that of Turkish cultivars except for Abasali and Akbari that are close to Uzun. Shokraii (1977) stated that Turkish pistachios were richer in protein 1.3 times compared to Kerman, Iran pistachio. However, the values obtained in our study are in agreement with the results of other researches about protein.

Total fat content of cultivar ranges were between 52.482 and 60.647%. The differences between fat content of cultivar studied, were statistically significant. The highest fat has been determined in Akbari (60.647%) and Khanjari (59.703 %). Shahpasand cultivar has been determined to have the least fat ratio (52.482%). In general total fat values determined in the cultivar are concordant with finding of other researches. Nevertheless, there are some differences (Table 2). Okay [24] stated that these differences in determined fat contents of pistachio cultivars might arise due to differences in factors like rising conditions, crop or season. Different rising regions, rootstocks or irrigation conditions had been reported to affect the fat ratio of cultivars [17].

Fatty acids profile

The chromatogram of one pistachio oil sample is shown in Fig1. Obviously, in pistachio oil, oleic, linoleic and palmitic acids have higher concentration rather than other fatty acids.

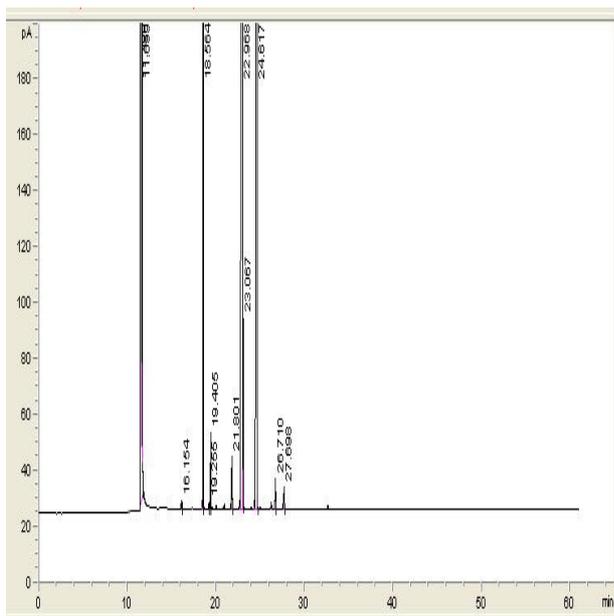


Fig.1. Chromatogram of fatty acids profiles of the pistachio oil obtained by GC-FID : 16.164 min (miristic acid), 18.554 min (palmitic acid), 19.714min (palmitoleic acid), 21.801 min (stearic acid), 22.968min (oleic acid), 24.617min (linoleic acid), 26.710min (arachidic acid), 27.698min (linolenic acid).

The composition profiles for saturated and unsaturated fatty acids of pistachio oil are presented in Tables 1 and 2 respectively. The saturated fatty acids in analyzed cultivars have been determined as palmitic acid (10.2275- 11.1075%), miristic acid (0.0810- 0.1080%), stearic acid (1.4150- 1.1010%) and arachidic acid (0.3885- 0.6300%). Regarding saturated fatty acids content, there has been no statistically significant difference between cultivars. The highest palmitic ratio (10.1075% ) has been determined in Kaleghouchi which is followed by Khanjari (10.8920%), Shahpasand

Table 2. Fat content of some pistachio cultivars

Pistachio cultivar	Fat (%)	Reference
Pistachio (general)	60.10 – 58.96	Ayfer et al, (1974)
Montaz (Iran)	55.40	Nizamoglu et al,(1995)
Montaz (Iran)	67.2	Garcia et al, (1992)
Siirt (Turkey)	54.2	Garcia et al, (1992)
Ohadi (Iran)	56.2	Garcia et al, (1992)
Montaz (Iran)	60.61	Kafkas et al, (1995)
Siirt (Turkey)	51.77	Kafkas et al, (1995)
Ohadi (Iran)	54.70	Kafkas et al, (1995)
Pistachio (general)	44.7 – 58.9	Kornsteiner et al, (2006)
Ohadi (Iran)	57 – 58.4	Kamangar and Farsam (1977)
Uzan (Turkey)	56.448	Okay (2002)
Siirt (Turkey)	55.852	Okay (2002)
Kirmizi (Turkey)	58.719	Okay (2002)
Halebi (Turkey)	56.110	Okay (2002)
Ohadi (Iran)	59.728	Okay (2002)

(10.8765%), Akbari (10.2590%) and Absali (10.2275%). The highest and lowest content of stearic acid found in Khanjari (1.4150%) and Kaleghouchi (1.1010%). The miristic acid and arachidic acid were only in traces. Mohamadi et al (2007) reported the palmitic acid content in seven Iran's pistachio cultivar originated from Rafsanjan as Ohadi (7.2%), Akbari (7.1%), Fandoghi (8.6%), Ahmadaghayi (8.2%), Kaleghouchi (7.8%), Fandoghi riz (8.3%) and Badami zarand (7.1 %). Also Okay (2002) presented acid palmitic in Turkish pistachio as Uzan (10.200%), kirmizi

(9.926%), Halebi (10.560%), Siirt (10.066%) and for Ohadi originated from Iran (10.280%). It is clear, our results about palmitic acid in pistachio

cultivar originated from Damghan region are higher than that of Mohammadi [23] and are close to the results of Okay [24].

**Table 3.** Saturated fatty acid content (%) of Damghan pistachio cultivars obtained by GC/FID.

Pistachio cultivar	Saturated fatty acids (%)			
	Myristic	Palmitic	Stearic	Arachidic
Akbari	0.100 0±0.02 <sup>a*</sup>	10.2590±0.003 <sup>a</sup>	1.2535±0.03 <sup>a</sup>	0.3885±0.05 <sup>a</sup>
Kaleghouchi	0.1080±0.001 <sup>a</sup>	11.1075±0.001 <sup>a</sup>	1.1010 ±0.001 <sup>a</sup>	0.4605±0.61 <sup>a</sup>
Khanjari	0.0185 ±0.01 <sup>a</sup>	10.8920±0.01 <sup>a</sup>	1.4150±0.02 <sup>a</sup>	0.6300±0.03 <sup>a</sup>
Abasali	0.0840±0.005 <sup>a</sup>	10.2275 ±0.01 <sup>a</sup>	1.2700±0.001 <sup>a</sup>	0.5810 ±0.01 <sup>a</sup>
Shahpasand	0.0810±0.06 <sup>a</sup>	10.8765±0.2 <sup>a</sup>	1.2475±0.002 <sup>a</sup>	0.4795±0.02 <sup>a</sup>

\*The data for saturated fatty acids content were reported as mean±standard deviation

\*\*Same letter indicates no significantly difference at p < 0.05.

Unsaturated fatty acid (UFA) contents were significantly different (P< 0.05) in studied cultivars. The oleic acid has been found to be commonest UFA containing a double bond. The oleic acid level has been found highest in Khanjari (55.2435%) and followed by Abasali (52.5555%), Shahpasand (51.8590%), Akbari (51.3625%) and kaleghouchi (48.9615%). The second fatty acid that had the highest concentration in fatty acid profile of pistachio oil was linoleic acid. In addition linoleic acid has the highest percentage (30.4820-36.8840%) among poly unsaturated fatty acid, whereas linolenic acid content is much less

(0.3590- 0.8405%). The highest level of linoleic acid content related to Kaleghouchi (36.8840%), Akbari (34.8230%), Shahpasand (34.0940%) cultivars and the lowest level were found in Abasali (33.9315%) and Khanjari (30.4820%) cultivars. Regarding linolenic acid which had three double bonds, there had been no statistically difference among studied cultivars. Linolenic acid content varied from 0.3590 % (Kaleghouchi) to 0.8405 % (Akbari). Comparing UFA in pistachio oil was revealed that the linolenic and palmitoleic acids content of studied cultivars were in traces.

**Table4.** Unaturated fatty acid content (%) of Damghan pistachio cultivars obtained by GC/FID.

Pistachio cultivar	Unsaturated fatty acids (%)			
	Palmitoleic	Oleic	Linoleic	Linolenic
Akbari	0.9130±0.003 <sup>b**</sup>	51.3625 ±0.01 <sup>ab</sup>	34.8230±.005 <sup>b</sup>	0.8405±0.03 <sup>a</sup>
Kaleghouchi	1.0180±0.02 <sup>c</sup>	48.9615 ±0.002 <sup>a</sup>	36.8840 ±.01 <sup>c</sup>	0.3590±0.05 <sup>a</sup>
Khanjari	0.8870 ±0.01 <sup>b</sup>	55.2435±0.05 <sup>c</sup>	30.4820±.023 <sup>a</sup>	0.3615±0.023 <sup>a</sup>
Abasali	0.8175±0.05 <sup>a</sup>	52.5555 ±0.21 <sup>bc</sup>	33.9315 ±0.051 <sup>b</sup>	0.3855±0.001 <sup>a</sup>
Shahpasand	0.9050±0.001 <sup>b</sup>	51.8590 c±0.04 <sup>c</sup>	34.0940 b±.014 <sup>b</sup>	0.3940±0.02 <sup>a</sup>

\*The data for unsaturated fatty acids were reported as mean±standard deviation

\*\*Same letter indicates no significantly difference at p < 0.05.

Mohamadi [23] presented oleic acid and linoleic acid content of pistachios originated from

Rafsanjan (Iran) ranges between 53- 77.6 % to 15.2- 38.6% respectively. However our results

about saturated and unsaturated fatty acids profile are in agree with other researchers. Oleic acid and linoleic acid content in Damghan pistachio cultivars are higher than Turkey's pistachio

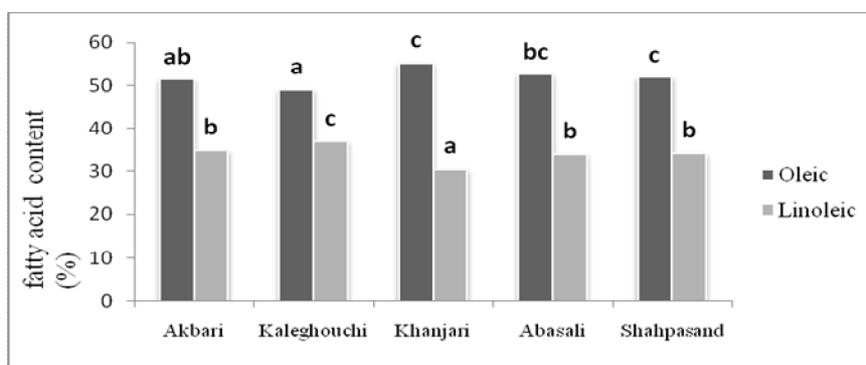
cultivars and Iran's cultivar (Ohadi) in Okay [24] research. Total amount of saturated and unsaturated fatty acids and the ratio of unsaturated ones to unsaturated ones are given in Table 5.

**Table 5.** Total saturated and unsaturated fatty acids content of Damghan pistachio cultivars

Pistachio cultivar	Saturated fatty acids (%)	Unsaturated fatty acids (%)	Unsaturated/Saturated
Akbari	12	88	7.4
Kaleghouchi	12.8	87.3	9.6
Khanjari	13.1	87	6.7
Abasali	12.2	87.7	7.2
Shahpasand	12.7	87.3	6.9

Okay [24] showed the ratio of unsaturated/saturated acids in Turkey's pistachio are 6.48-7.4 and in Ohadi (Iran) is 7.27. Agar [1] stated this ratio for Turkey's pistachio is 7.90 and for Iran's pistachio is 9.48. According Mohammadi [23] this ratio in Rafsanjan pistachio cultivar are 10.6 – 13. Therefore our results are in agreement with others.

Fig. 2 showed the comparison of oleic and linoleic acid content in studied pistachio cultivars. Obviously, there is an inverse correlation between oleic acid and linoleic acid content in pistachio oil. In spite of the highest linoleic acid content, the oleic acid content is at least in Kaleghouchi cultivar.



**Fig 2.** Comparison of oleic and linoleic acid content of Damghan pistachio cultivars

Comparing the commonest fatty acid including oleic, linoleic and palmitic acids in pistachio originated from Damghan (this research), Rafsanjan [23] and Turkey [24] showed that the linoleic acid and palmitic acid content in Damghan

pistachio are higher than Rafsanjan's and turkey's pistachio (Fig 3). Since linoleic acid is an essential fatty acid, it can be said that the nutritional value of Damghan pistachio cultivar is noticeable.

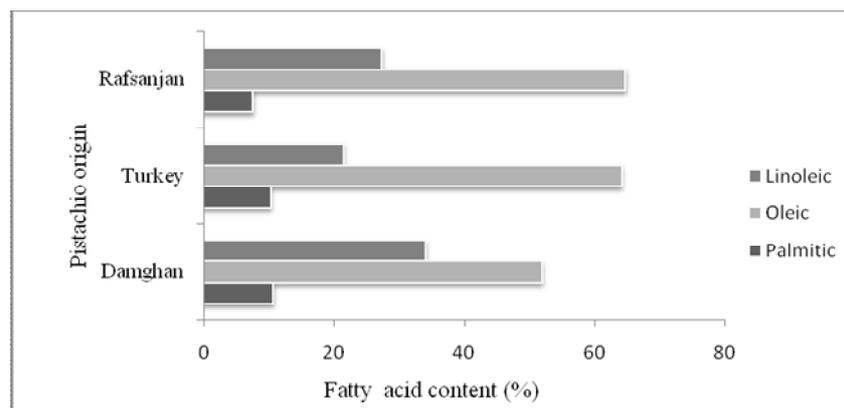


Fig 3. Comparison of the commonest fatty acids (oleic acid, linoleic acid and palmitic acid) in pistachio originated from Rafsanjan (Mohamadi et al, 2007), Turkey (Okay, 2002) and Damghan.

### CONCLUSIONS

Determination of protein, fat and fatty acid composition in Damghan pistachio cultivar showed that regarding protein and fat contents the Abasali and Akbari cultivars respectively were higher than other cultivars. According fatty acid composition, Damghan pistachio cultivars were similar to other cultivars that originated from different regions in the world. Comparing fatty acid content in cultivars indicated the amount of linoleic acid as an essential fatty acid is very high especially in Kalwghouchi cultivar. Therefore, the nutritional value of Damghan pistachio cultivars is considerable. These findings obtain good information for new plantation program and should be consider as important quality factors for marketing.

### ACKNOWLEDGEMENTS

The authors wish to thank Food and Drug Administration and quality control laboratory of Semnan University of Medical Sciences for helping in doing experiment.

### REFERENCES

1. Agar, I.T.; Sarmiento, R.; Garces, N.; Kaska, Kafkas.; et al., (1995). Compositional changes of fatty acids during the development of embryo in pistacia vera. *Acta-Horticulturae.*, 491, 405-401.
2. Agar, I.T, (1998). Llipid characteristics of Turkish and Iranian pistachio kernels. *Acta-Horticulturae.*, 470, 378-384. Anonymous, <http://www.foss.dk/solutions/productsdirect/sox-tecsystems.aspx>,(2006).
3. AOAC , official Method 947.07 Fatty Acids (Water-Insoluble) (WIA) in But ter (Polenske Num ber) Gravimetric MethodFirst Action (1947) Final Action.
4. AOAC official Method 996.01 , Fat (Total, Saturated, Unsaturated, and Monounsaturated) in Cereal Products Acid Hydrolysis Capillary Gas Chromatographic Method First Action (1996).
5. Arena,E.; Campisi, S.; Fallico,B.; Maccarone,E., (2007). Distribution of fatty acids and phytosterols as a criterion to discriminate geographic origin of pistachio seeds. *Food Chemistry.*, 104, 403–408.
6. Arranz,S.; Cert,R.; Pérez-Jiménez,J.; Cert,A.; Saura-Calixto,F.,(2008). Comparison between free radical scavenging capacity and oxidative stability of nut oils. *Food Chemistry.*, 110 , 985–990.

7. Aslan, M.; Orfan, I.; Sener, B., (2002). Comparison of the seed oils of pistacia vera L. of different origins with respect to fatty acids. *Int Journal of Food Science and Technology.*, 37, 333-335.
8. Aslan, M.; Orhan, I., (2006). Fatty acid patterns of waste parts of Turkish *Pistacia Vera* L. tree. *Actabio Series Botanica.*, 48 (2), 117–120.
9. Ayfer, M., (1973). Investigation on the quantity of oil and the kind and properties of fatty acids in the fruits of some important pistacia species and the possibilities of their use in biochemical systematic. *Yalova Bache Kulturleri Arastirma VE Egitim Merkezi Dergisi.*, 6 (1-2), 25-40.
10. Azlan, A.; Nagendra Prasad, K.; Khoo, H.; Abdul-Aziz, N.; Mohamad, A.; Amin Ismail, Zulkhairi Amom, (2010). Comparison of fatty acids, vitamin E and physicochemical properties of *Canarium odontophyllum* Miq. (dabai), olive and palm oils. *Journal of Food Composition and Analysis.*, 23 , 772–776.
11. Bellomo, M.; Fallico, B., (2007). Anthocyanins, chlorophylls and xanthophylls in pistachio nuts (*Pistacia vera*) of different geographic origin. *Journal of Food Composition and Analysis.*, 20 , 352–359.
12. Cao, Y.; Suo, Y., (2010). Extraction of *Microula sikkimensis* seed oil and simultaneous analysis of saturated and unsaturated fatty acids by fluorescence detection with reversed-phase HPLC. *Journal of Food Composition and Analysis.*, 23 , 100–106.
13. Combe, N., (2002). Bioavailability of fatty acid and population reference intake. *Lipids.*, 9 (2/3), 135-138.
14. Costa, P.; Costa, F.; A., Lopes. P. A.; Alfaia C.M.; Bessa, R.J.B.; Roseiro L.C., (2011). Fatty acid composition, cholesterol a-tocopherol of Barrosa~PDO veal produced in farms located in lowlands, ridges and mountains. *Journal of Food Composition and Analysis.*, 45, 654-658.
15. Daneshrad, A., (1987). The structure of the glycerides of pistachio kernel oil. *Journal of the American oil Chemists Society.*, 55(3), 317-319.
16. Hidalgo, F.J.; Zamora, R., (2006). Peptides and proteins in edible oils: Stability, allergenicity, and new processing trends. *Trends in Food Science & Technology.*, 17, 56–63.
17. Kamangar, T.; Farsam, H., (1977). Chemical composition of pistachio kernels of various Iranian origin. *Journal of Food Science.*, 42, 1135-1138.
18. Kumari, P.; Reddy .C.R.K.; Jha, B., (2011). Comparative evaluation and selection of a method for lipid and fatty acid extraction from macroalgae. *Analytical Biochemistry.*, 415, 134–144.
19. Kyle Rodriguez., (2005). Nutritional Differences of Pistachio Nuts and Pistachio Butter. *NTRS.*, 519, Summer.
20. Lee. A. K.; Yun, a. I. J.; Hee Kim, a.; Lim, a.; Hamb, H.; Eumc, K.; HoJoo, J., (2011). Amino acid and fatty acid compositions of *Agrocybe chaxingu*, an edible mushroom. *Journal of Food Composition and Analysis.*, 24 , 175–178.
21. Mapekula, M.; Chimonyo, M.; Mapiye, C.; Dzama, K., (2011). Fatty acid, amino acid and mineral composition of milk from Nguni and local crossbred cows in South Africa. *Journal of Food Composition and Analysis.*, 24 , 529–536.

22. Mezzomo, N.; Mileo, B.; Friedrich, M.T.; Martínez, J.; Ferreira, S.R., (2010). Supercritical fluid extraction of peach (*Prunus persica*) almond oil: Process yield and extract composition. *Bioresource Technology*, 101, 5622–5632.
23. Mohammadi, N.; Safari, M.; Fatemi, S.H.; Hamed, M., (2007). Positional distribution of three major fatty acid in oil of seven important varieties of pistachio (*Pistachio vera* L., Anacardiceae) according to the 1,3-random, 2-random theory. *J Agric Sci Nature*, 14(1), Apr- May.
24. Okay, Y., (2002). The Comparison of some Pistachio Cultivars Regarding their Fat, Fatty acids and Protein Content. *Gartenbauwissenschaft*, 67 (3), 107–113.
25. Pe´rez-Jime´nez, J.; Arranz, S.; Taberner, M., (2008). Updated methodology to determine antioxidant capacity in plant foods, oils and beverages: Extraction, measurement and expression of results. *Food Research International*, 41, 274–285.
26. Prandini, A.; Sigolo, S.; Piva, G., (2011). A comparative study of fatty acid composition and CLA concentration in commercial cheeses. *Journal of Food Composition and Analysis*, 24, 55- 61.
27. Ruiz-Rodriguez, A.; Reglero, G.; Ibanez, E., (2010). Recent trends in the advanced analysis of bioactive fatty acids. *Journal of Pharmaceutical and Biomedical Analysis*, 51., 305–326.
28. Sahena, F.; Zaidul I.S.M S.; Jinap ,A.M.; Yazid, A.; Khatib, N.A.N.; Norulaini., (2010). Fatty acid compositions of fish oil extracted from different parts of Indian mackerel (*Rastrelliger kanagartha*) using various techniques of supercritical CO<sub>2</sub> extraction. *Food Chemistry*, 120, 879–885.
29. Satil, F.; Azcon, N.; Baser, K. H. C., (2003). Fatty acid composition of pistachio nuts in Turkey. *Chemistry of Natural Compounds*, 39, 322-324.
30. SchaÈfer, K., (1998). Accelerated solvent extraction of lipids for determining the fatty acid composition of biological material. *Analytica Chimica Acta*, 358, 69-77.
31. Seferoglu, S.; Seferoglu, H.G.; Tekintasa, F.E.; Balta, F., (2006). Biochemical composition influenced by different locations in Uzun pistachio (*Pistacia vera* L.) grown in Turkey. *Journal of Food Composition and Analysis*, 19, 461–465.
32. Sheibani, A.; Ghaziaskar, H., (2008). Pressurized fluid extraction of pistachio oil using a modified supercritical fluid extractor and factorial design for optimization. *LWT*, 41, 1472–1477.
33. Tan, H.; Ghazali, H.m.; Kuntom, A.; Tan, C.; Ariffin, A., (2009). Extraction and physicochemical properties of low free fatty acid crude palm oil. *Food Chemistry*, 113, 645–650.
34. Velasco, J.; Andersen, L.; Skibsted L., (2004). Evaluation of oxidative stability of vegetable oils by monitoring the tendency to radical formation. A comparison of electron spin resonance spectroscopy with the Rancimat method and differential scanning calorimetry. *Food Chemistry*, 85, 623–632.
35. Yang, J.; Liu, R.; Halim, L., (2009). Antioxidant and antiproliferative activities of common edible nut seeds. *LWT - Food Science and Technology*, 42, 1–8

36. Yang, J.2009. Brazil nuts and associated health benefits: A review. *LWT - Food Science and Technology* 42 ,1573–1580.