Selcuk J Agr Food Sci, (2018) 32 (1), 73-80

e-ISSN: 2458-8377 DOI: 10.15316/SJAFS.2018.67

Selcuk Journal of Agriculture and Food Sciences

Determination of Chemical and Physical Properties for Seeds and Oils of Some Different Oleic and Linoleic Sunflower Types

Buket AŞKIN

Kırklareli University, Faculty of Engineering, Food Engineering Department, Kırklareli, Turkey

ARTICLE INFO

Article history:

Received date:15.12.2017

Accepted date: 27.03.2018

Keywords:

Linoleic

Oil

Oleic

Seed

Sunflower

ABSTRACT

Chemical and physical properties of six different sunflowers of high oleic and linoleic cultivars and their extracted oils were determined. For each seed cultivar, there were determined thousand-grain weight, test weight, moisture and ash. Oil content ranged from 36.28 to 43.01 %. Predominant fatty acids in oils extracted from high oleic types were oleic acid from 69.44 to 87.23 % and linoleic acid content from 44.05 to 52.93 % for linoleic types. The total phenol content (TPC) of the oils ranged from 35 to 66 mg 100 g-1 of oil for oleic cultivars and from 24 to 87 mg 100 g-1 of oil for linoleic cultivars. Non-parametric mann-whitney test was performed to the TPC data and asymptotic significance value was determined as 0.690, so significant differences were not determined between oleic and linoleic types. According to the IC50 value, LG5400 had the highest was significantly different from others. It was also observed a significant difference for refractive index and iodine value and no significant difference for saponification values between oils. The study showed characterization for different types of seed oil that has made it possible to comment on industrial quality.

1. Introduction

Sunflower is one of the major oilseed crop worldwide (Gouzy et al., 2016). Whereas traditional sunflower is so abundant with linoleic acid, the worldwide demand to oleic-type sunflower has been increasing gradually. Turkey is a big potential for oleic-type sunflower oil because sunflower oil consumption of around 10 million MT for worldwide is digested by Turkish people about 600–700 tons (Kaya et al., 2008).

Linoleic acid reduces to the saturation and facilitates to the digestion and passes the blood. The greater amount of linoleic acid in the oil increases the oil quality. However, high linoleic acid content in sunflower oil affects to the industrial value. Linoleic sunflower oil usually use in salads, meals, margarines and shortenings. High oleic sunflower oil is used in generally spray oil in crackers, dried fruits, bakery products, frying, deep oil frying, roast process, salads and sauces, food supplements specialized for adults and children and as mixture oil in margarine and mayonnaise. Fatty acid composition not only affects to the industrial quality but also nutritional value is also affected at the same time. Fatty acid composition affects to the taste and chemical quality of oil. The phenolic compounds in sunflower oil have effective role on taste aroma, oxidation level and rate.

In this research, the three types of high oleic (LG5400, P64H34, Colombi) and the three types of linoleic sunflower seeds (LG5580, P64G46, 08TR003) were analysed that they have been registered in the Food Ministry in Turkey. All these seed cultivars have been poorly studied, meaning that no complete characterization of these seeds. However, they have been used for oil production industrially.

2. Material and Methods

2.1. Materials

Six different cultivars were analysed three of them, LG5400, P64H34, Colombi, had high oleic background and others, LG5580, P64G46, 08TR003, had linoleic background. All seed samples were supplied from research fields of Directorate of Trakya Agricultural Research Institute in Edirne for 2014-2015 harvest term. Commercial hybrids of linoleic types and oleic types were P64G46 and P64H34 belong to Pioneer Seed Co, LG5400 and LG5580 belong to Limagrain Seed, Colombi belongs to Sygenta Seed Company and 08TR003 belongs to Trakya Agricultural Research Institute.

* Corresponding author email: *buketaskin@klu.edu.tr*

Due to their low humidity, seeds were stored in a dark and dry place at room temperature. All chemicals and solvents used were chromatographic or HPLC grade.

2.2. Methods

Seed Characterization

This experiment was conducted in Food Engineering Laboratory of Kırklareli University in 2016. Experimental design was based on randomized completely design with 3 replicates for all seeds. In the first step, it was separated thousand seeds from each sunflower seed cultivars and weighed (Doğan, 2010). Then, the test weight was determined to the weight of 1liter volume for samples (Anonymous, 2001). The husk ratio was also analyzed. For this purpose, seeds (4x100 pieces) separated from the inner and outer shells and then both shells are stored at 105 ° C in a dryer cabinet before weighed. The last values were expressed on the average shell weight (Anonymous, 2001). Also, moisture content and ash content were determined using AOCS Ca2c-25 and AOCS Ca11-55 standard methods, respectively. Results were expressed in percentage dry basis.

Oil extraction

Oil content was determined using the IUPAC (1992) 1.122 standard method by continuous extraction in a soxhlet apparatus. For each extraction 100 g of grinded seeds were used and the solvent employed was n-hexane. Totally, 3 kg seed for each cultivar was extracted by soxhlet extraction. Results were expressed in percentage dry basis. Extracted oil samples were stored under refrigeration conditions in dark brown glass bottles until analyses.

Oil analyses

Preparation of extracts for chemical analysis: The oil (5 g) was dissolved by 5 mL of n-hexane for 2 minutes and after extracted with 5 mL of methanol:water (60:40 v:v) for three times and shaken by vortex for 2 minutes in order to extract the phenolic and antioxidant components. Besides, samples were centrifuged for 10 minutes with 3500 rpm at 20 °C. After the first centrifugation, the phase of methanol:water was transferred to another place and the residue was extracted by methanol:water (60:40 v:v) for two times. The combined extracts were vacuum evaporated to remove the solvent then weighed to determine the extraction yield, and stored at -20 °C until use.

Folin-Ciocalteu Assay: Total phenolic compounds (TPC) were determined in sample extracts using the Folin-Ciocalteu reagent as per the method described by Singleton and Rossi (1965) with slight modifications. Briefly, suitable volumes of sample extract to fit into standard concentrations were taken, 0.25 mL of 10% Folin-Ciocalteu reagent and 0.5 ml of Na2CO3 were added, vortexed thoroughly and incubated at room temperature for 60 minutes and the absorbance was read at 720 nm. The values were expressed as equivalents of gallic acid, which is one of the most commonly, used standards in phenolic estimations.

DPPH Radical Scavenging Activity: DPPH radical scavenging activity was determined according to Blois (1958). This method is based on the ability of the antioxidant to scavenge the DPPH cation radical. Briefly, sample extract or standard with 5 different concentartions (50 mcg, 100 mcg, 150 mcg, 200 mcg, 250 mcg) was added to DPPH reagent (0.1 mM in methanol) and vortexed vigorously and volume up to the 6 mL. The reaction tubes were incubated in dark for 15 minutes, at room temperature and the discolouration of DPPH was measured against a reagent blank at 517 nm. Percentage inhibition of the discolouration (IC50 values) of DPPH by the sample extract was calculated and expressed as trolox equivalents (Karacabey et al., 2016).

Fatty Acid Composition: The fatty acid compositions were determined for extracts of oils. For determination of fatty acid compositions for oil samples, methyl esters were prepared using IUPAC (1987) and fatty acid composition AOCS (1997) method. The samples (1 mL for each sample) were esterified by 1 mL of Na-Metilante (0.5 g Na-Metilante + 80 mL methanol + 20 mL iso-octane). Before injection, 0.25 mL of iso-octane was added to the each esterified sample and then the tube was thoroughly rinsed. 0.5 mL of the clarified top phase was given by microinjection was injected, via an automatic sampler, into the Gas Chromatography and mass spectroscopy (GC-MS). The GC-MS was equipped with a CP select CB 50 m capillary coloumn (D:0.32 mm). The initial oven temperature was maintained at 60 °C for 4 min, then firstly increased at a rate of 4 °C min-1 to 175 °C for 27 min and later increased a rate of 4 °C min-1 to 215 °C for 5 min and finally reached to the last temperature to 240 °C with again increased a rate of 4 °C min-1.

Main Quality Parameters of Oils: Refractive index of virgin olive oil samples was measured in daylight with 60/70 Abbe Refractometer, calibrated against pure water at 25 ˚C. Saponification value, given as mg KOH g-1 oil, was determined in accordance with the AOCS Cd3a-94 (1997) and iodine value (g I2 100 g-1 oil) determined by the AOCS Cd1c-85 (1997). All parameters were determined in triplicate for each sample.

Statistical analyses

Nonparametric two-sample Mann-Whitney test was used to study the treatments. Because the data was not normally distributed and the amounts of samples were small, all the statistical analyses were done with nonparametric tests. Oleic varieties and linoleic varieties were compared for some properties by nonparametric Mann-Whitney test.

Table 1
Physicochemical properties of different varieties of sunflower seeds

Sample	*1000SW*	*Test Weight*	*Husk*	*Moist.*	*Ash*
P64G46	64.51b±2.45	428.27cd±9.06	51.56a±0.23	4.85±0.25	3.35±0.02
LG5580	57.41d±0.54	407.26d±4.62	50.46a±0.92	5.68±0.04	4.63±0.19
08TR003	74.87de±0.95	472.68bc±2.58	51.61a±0.73	5.42±0.16	3.53±0.21
P64H34	60.59e±0.85	404.79d±1.25	51.10a±0.73	4.96±0.14	3.36±0.04
COLOMBİ	59.56c±1.31	424.70b±11.38	49.70a±1.26	5.29±0.28	2.98±0.06
LG5400	67.32a±0.97	415.52a±1.94	50.96a±0.17	5.83±0.22	3.48±0.15
P64G46	64.51b±2.45	428.27cd±9.06	51.56a±0.23	4.85±0.12	3.35±0.19
LG5580	57.41d±0.54	407.26d±4.62	50.46a±0.92	5.68±0.33	4.63±0.22
08TR003	74.87de±0.95	472.68bc±2.58	51.61a±0.73	5.42±0.29	3.53±0.27

Note: Means with different letters differ significantly at P< 0.05.

Table 2

The correlation coefficients between some physicochemical properties and percentage of moisture and ash belong to the sunflower seeds

r	*1000SW*	*Test Weight*	*Husk*	*Moist.*	*Ash*
1000SW	1				
Test W.	0.829**	1			
Husk	-0.172	-0.233	1		
Moist.	0.121	-0.15	-0.509*	1	
Ash	-0.229	-0.192	-0.020	0.463	1

**: P < 0.05; ** : P > 0.01*

3. Results and Discussions

3.1. Physicochemical Composition of Sunflower Seeds

Table 1 showed the seed composition. Moisture content obtained for each cultivar was accordance with vast majority of literature (Baydar and Erbaş, 2005; Salaberria et al 2016) but far away to the upper limit of the some researches (Fisk, 2007; Mourad et al., 2017). Ash contents of all seeds were parallel with other research.

Besides, Table 2 shows the correlation coefficients between some physical properties and percentage of moisture and ash belong to the sunflower seed. As expected, the highest positive and significant correlation (r = 0.829**) were determined between test weight and thousands seeds weight. Also, it was determined that negative significant relationship (r =-0.509*) between average husk ratio and percentage of moisture. Otherwise, there were not any relation between oleic and linoleic types for these properties.

Likewise, no significant differences in oil contents were found between the six cultivars (Table 3). However, the highest content belonged to 08TR003 is linoleic seed. Colombi and LG5580 have been to the lowest oil content. However, there were not significant differences between oleic and linoleic types.

There are not enough researches for these varieties or different sunflower varieties or comparing for oleic and linoleic sunflower types. However, the results could be compared with registration reports of the food ministry in Turkey.

Table 3

Oil contents (dw%) of sunflower cultivars

Cultivars	*Oil Content (dw%)*
P64G46	41.55a±0.61
LG5580	41.09ab±2.17
08TR003	36.76ab±1.44
P64H34	36.28ab±1.06
COLOMBİ	41.09b±0.77
LG5400	43.01ab±1.71
P64G46	41.55a±0.61
LG5580	41.09ab±2.17
08TR003	36.76ab±1.44

Note: Means with different letters differ significantly at $P< 0.05$.

The reports contain to the plant characteristics, oil content and physical seed properties of these varieties. In 2013-2014, oil contents of varieties were slightly higher than those of the 2014-2015 results. Besides, the test weights and husk ratios were also slightly higher for 2014-2015 than 2013-2014 years (Anonymous, 2015; Evciet al., 2016). These findings may reflect the differences in climatic conditions between two different harvest seasons. Otherwise, the methodology was also affected to the results for oil content especially.

Table 4.

The fatty acid composition of the different varieties of sunflower seeds

Fattyacids			*Sample*					
			Oleicvarieties			*Linoleicvarieties*		
RT		*Methylester*	LG5400	P64H34	Colom-bi	LG5580	P64H46	08TR003
18.99	C16:0	Palmitic	4.83	5.67	3.34	5.77	4.89	5.39
19.70	C16:1	Palmitoleic	0.17	0.11	0.02	0.05	0.05	0.08
21.21	C17:0	Heptadecanoic	0.03	0.04	0.01	0.03	0.02	0.03
21.81	C17:1	C-10heptadecanoic	0.03	0.04	0.01	0.02	0.01	0.02
22.44	C18:0	Stearic	2.75	3.35	3.08	4.19	4.88	5.30
23.52	C18:1n9c	Oleic	72.36	69.44	87.23	36.6	43.57	44.63
24.97	C18:2n6c	Linoleic	19.3	20.88	5.72	52.93	46.12	44.05
27.64	C183n6	Gama linolenic	0.29	0.32	0.36	0.32	0.24	0.41
27.98	C18:3n3	Linolenic	0.24	0.15	0.23	0.09	0.22	0.09

Oil Characterisation

Classical sunflower oil fatty acid composition is saturated acids 11 % (stearic, palmitic), oleic 20 % and linoleic acid 69 % and it has a large utilization for cooking or margarine (Baydar and Erbaş, 2005; Evci et al., 2016). Table 4 shows to the fatty acid composition of the different varieties of sunflower seeds. Fatty acid composition was determined by gas chromatography according to the official analysis method. It is expected, high oleic types in oleic background have high oleic acid content.

Major fatty acid composition in cultivars was in agreement with contents mentioned among literatures and registration reports of the food ministry in Turkey. The relative percentages of fatty acids obtained for oleic cultivars were not very similar (Table 4).

Colombi involved in high oleic group and so that has the Major fatty acid composition in cultivars was in agreement with contents mentioned among literatures and registration reports of the food ministry in Turkey. The relative percentages of fatty acids obtained for oleic cultivars were not very similar (Table 4). Colombi involved in high oleic group and so that has the highest oleic acid content with 87.23 % between oleic varieties. LG5400 and P64H34 types have 72.36 % and 69.44 % oleic acid percentages, respectively so that these hybrids were categorized as mid oleic type. The most abundant fatty acid was oleic acid followed by linoleic acid, palmitic acid and stearic acid. The major polyunsaturated fatty acid was linoleic acid (n-6 PUFA) while only traces of n-3 PUFAs (C183n6; C18:3n3) were found.

The standard linoleic genotypes showed the highest mean linoleic acid content and determined as 36.6 % (at LG5580), 43.57 % (at P64H46) and 44.63 % (at 08TR003). Large differences in linoleic and oleic content were observed firstly among the linoleic genotypes.

The ratio of the fatty acids for both groups of genotypes has accordance with literatures. There were some little differences for values, especially for oleic genotypes, because of environmental factors and genetic factors (Pacureanu et al., 1999; Pacureanu et al., 2005; BaydarandErbas, 2005; Izquierdo et al., 2006; Fernandez Martinez et al., 2009; Demurinand Borisenko, 2011). Besides, growth conditions have a large impact on the fatty acid organization of the sunflower oil. Warmer climatic conditions generate more monounsaturated fatty acid MUFA oleic acid and less n-6 polyunsaturated fatty acid (PUFA) and linoleic acid (an essential fatty acid, EFA) in comparison to colder climatic conditions (Khan et al., 2015; Morrison et al., 1995).

Phenolics and polyphenolic compounds are thought to contribute directly to antioxidative action and they constitute the main class of natural antioxidants present in plants (Awika et al., 2003; Nadeem et al., 2011) therefore it is necessary to calculate total phenolic content in sunflower seeds and declined to the relation between TPC and Radical Scavenging Activity. TPC was determined following a Follin– Ciocalteu method and results were expressed as gallic acid equivalents.

It is expected that sunflowers have low TPC. The results were given in figure 1 and the highest phenolics content (87 mg GAE 100 g g-1) was found in oil extracted from 08TR006 follwed by P64H35. Besides, P64G46 oil has the lowest value for TPC. There were no statistical relation between TPCs of oils and oleic and linoleic varieties. Non-parametric mann-whitney test was performed to the TPC data and asymptotic significance value was determined as 0.690, so significant differences were not determined between oleic and linoleic varieties.

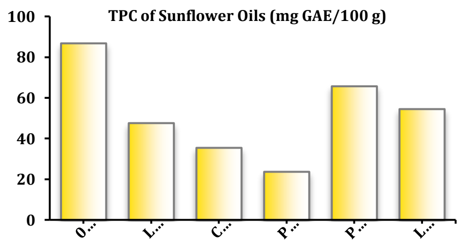

Figure 1

Total Phenolic Content of Sunflower Oils (mg GAE 100 g-1)

According to the IC50 values (Table 5), LG5400 has the highest value and it is significantly different from others. Besides, LG5580 and P64G46 have the lowest value for IC50. Different results have been reported on the aspect of relationship between phenolic content and antioxidant activity. Some scientists found correlation between the total phenolic contents and the antioxidant activity while some found no such relationship (Andarwulan et al., 1999). However, our findings showed no correlation between TPC and DPPH values. It was obviously obtained that declining in TPC was not accompanied by a comparative decrease for DPPH values.

Tsaliki et al (1999) also observed an increase in the antioxidant activity of lupin seed. Also a linear positive relationship existed between the antioxidant activity and total phenolic acids content of the tested Ocimumaccessions (Javanmardi et al., 2003). MaillardandBerset (1995) found no correlation between antioxidant activity and phenolic contents in malts and it was mentioned that other compounds are also responsible for the antioxidant activity. Also no relationship between

Table 5

DPPH RadicalScavenging Activity of SunflowerOils (Inhibition, %)

	Inhibition (%)					
SCE*(mcg)	LG5400	P64H34	COLOMBI	LG5580	P64H46	08TR003
50	39.96	22.65	16.04	5.94	5.79	12.81
100	54.37	36.61	26.06	10.33	12.02	19.73
150	74.75	55.74	38.09	15.24	18.72	28.18
200	84.52	67.07	49.41	20.15	21.83	37.15
250	98.99	77.67	53.47	25.58	25.84	46.12
IC50	81	143	218	482	482	276

**Samplecontent in extract*

Table 6

Some physicochemical characteristics of the sunflower oil samples

Sample	*RI*	*SV(mg KOH g^{-1} oil)*	*IV(g I_2 100 g^{-1} oil)*
LG5400	1.471	191	101
PR64H34	1.475	192	128
COLOMBI	1.470	191	89
LG5580	1.475	192	129
PR64H46	1.474	192	120
08TR003	1.474	192	120

antioxidant activity and phenolic composition was found in citrus residues (Boccoet al., 1998), fruit berry, fruit wines (Heinonen et al., 1998) or in plant extracts (Kahkonen et al., 1999).

The chemical characteristics of the sunflower oil samples were shown in Table 6. Results revealed that refractive indexes of the samples were not significantly different ($p<0.05$). Iodine value (IV) that represents the degree of unsaturation indicated that LG5580 and PR64H34 oils have higher value compared to the other oils. Regarding the ester value, saponification value (SV) results showed that all of the sunflower oil had nearly same values ($p>0.05$). Besides, there was a significant correlation between refractive index, iodine value and saponification value.

Conclusions

Complimentary fatty acid composition of sunflower has made it an important oil crop in the world. Traditional sunflower oil rich in linoleic acid is primarily used in the edible oil industry. Recently, significant progress has been made in fatty acid alteration of sunflower oil. Available advanced technologies including genetic modifications and marker assisted breeding should be efficiently exploited to transform the fatty acid composition of oils. In current scenario with enhanced risk of coronary heart diseases, improved research on producing healthier sunflower oil can play a crucial role. The high oleic type of sunflower, which contains > 85 % oleic acid, is considered to be highly valuable not only for the food industry but also for various technical uses as a basic material for the oleochemical industry.

It is the first research about these types of sunflowers and these findings would be useful to cultivators and consumers. The data of physicochemical and chemical properties of six different registered types and oils were obtained. In addition to our research, thermal stability and frying qualities of oleic and linoleic oils can be studied with different researches.

4. Acknowledgements

We express our sincerest gratitude to Trakya Agricultural Research Institute for supplying the seeds.

5. References

American Oil Chemists' Society (1997).*Official methods and recommended practices of the AOCS (5th ed.) (3a-94)*. Champaign: AOCS Press.

American Oil Chemists' Society (1997).*Official methods and recommended practices of the AOCS (5th ed.) (Cd1c-85).* Champaign: AOCS Press.

American Oil Chemists' Society (2009).*Official methods and recommended practices of the AOCS (6th ed.) (Ca2c-25).* Champaign: AOCS Press.

American Oil Chemists' Society (2009).*Official methods and recommended practices of the AOCS (6th ed.) (Ca11-55).* Champaign: AOCS Press.

Andarwulan N, Fardiaz D, Wattimena GA, Shetty K (1999). Antioxidant activity associated with lipid and phenolic mobilization during seed germination of PangiumeduleReinw. *Journal of Agricultural and Food Chemistry* 47: 3158-3163.

Anonymous (2001).*Ayçiçeği (Helianthus annus L.) tarımsaldeğerleriölçmedenemeleriteknik-talimatı.TarımveKöyişleriBakanlığıKorumaveKontrolGenelMüdürlüğüTohumlukTescilveSertifikasy-onMerkeziMüdürlüğü,* Ankara.

Anonymous (2015).*GidaTarimveHayvancilikBakanliğIBitkiselÜretimGenelMüdürlüğüTohumlukTescilveSertifikasyonMerkezMüdürlüğüEndüstri Bitkileri ÇeşitTescilRaporları,* Ankara.

Awika JM, Rooney LW, Wu X, Prior RL, Cisneros-Zevallos L (2003). Screening methods to measure antioxidant activity of sorghum (Sorghum bicolor) and sorghum products. *Journal of Agricultural and Food Chemistry* 51: 6657–6662.

Baydar H, Erbas S (2005). Influence of seed development and seed position on oil, fatty acids and total tocopherol contents in sunflower (*Helianthus annuus L.). Turkish Journal of Agriculture and Forestry* 29: 179-186.

Bocco A, Cuvelier ME, Richard H, Berset C (1998). Antioxidant activity and phenolic composition of citrus peel and seed extracts. *Journal of Agricultural and Food Chemistry* 46: 2123–2129.

Demurin Y, Borisenko O (2011). Genetic collection of oleic acid content in sunflower seed oil.*Helia* 34 (55): 69-74.

Dogan M (2010). A Research about defining technologic and agricultural properties of sun seed species under nonirrigable conditions.*Master Thesis, Cukurova University, Institute of Science and Technology*, Adana.

Evci G, Pekcan V, Yilmaz İ M, Cıtak N, Tuna N, Ay O, Pilaslı A, Kaya Y (2016). Determination of Yield Performances of Oleic Type Sunflower (Helianthusannuus L.) Hybrids Resistant to Broomrape and Downy Mildew.*Journal of Crop Breeding and Genetics* 2(1): 45-50.

Fernandez Martinez, JM, Perez Vich B, Velasco L (2009).*Sunflower. In: OilCrops, Handbook of PlantBreeding, V.4, Vollmann, J. andRajcan, I. (eds.),* 155- 232.

Fisk L (2007). Physico-Chemical Charactorisation of Sunflower Seed Oil Bodies Ex-vivo.*Thesis submitted to the University of Nottingham for the degree of Doctor in Philosophy*, March.

Gouzy A, Massol AP, Mouloungui Z, Merah O (2016). Effects of technical management on the fatty-acid composition of high-oleic and high-linoleic sunflower cultivars.*Oilseeds & fats Crops and Lipids* 23(5): 502.

Heinonen M, Lehtonen PJ, Hopia AL (1998).Antioxidant activity of berry and fruit wines and liquors.*Journal of Agricultural and Food Chemistry* 46: 25-31.

International Union of Pure, Applied Chemistry (IUPAC) (1992) *Standard methods for the analysis of oils, fats and derivatives, 7th edn*. Blackwell Scientic Publications, Oxford.

International Union of Pure, Applied Chemistry (IUPAC) (1987) *Standard methods for the analysis of oils, fats and derivatives, 7th edn*. Blackwell Scientic Publications, Oxford.

Izquierdo NG, Aguirrezábal LN, Andrade FH, Cantarero MG (2006). Modeling Response of Fatty Acid Composition to Temperature in a Traditional Sunflower Hybrid. *AgronomyJournal* 98: 451-461.

Javanmardi J, Stushnoff C, Locke E, Vivanco JM (2003). Antioxidant activity and total phenoliccontent of Iranian Ocimum accessions.*FoodChemistry* 83: 547-550.

Kahkonen MP, Hopia AI, Vuorela JH, Rauha JP, Pihlaja K, Kujala TS, Heinonen M (1999). Antioxidant activity of plant extracts containing phenolic compounds. *Journal of Agricultural and Food Chemistry* 47: 3954-3962.

Karacabey E, Ozkan G, Dalgıç L &Sermet S O (2016). Rosemary aromatization of extra virgin olive oil and process optimization including antioxidant potential and yield.*Turkish Journal of Agriculture Food Science and Technology* 4(8): 628-635.

Kaya Y, Kaya V, Şahin İ, Kaya MU, Evci G, Çitak N (2008). The future potential of oleic type sunflower in Turkey.*Current Status and New Uses of the Crop, Proc.* 17th International Sunflower Conference, Córdoba, Spain, 791-795.

Khan S, Choudhary S, Pandey A, Khan MK, Thomas G (2015).*Sunflower Oil: Efficient Oil Source for Human Consumption.* Emergent life sciences research 1(1): 1-3.

Maillard MN, Berset C (1995). Evolution of antioxidant activity during kilning: Role of insoluble bound phenolic acids of barley and malt. *Journal of Agricultural and Food Chemistry* 43(7): 1789–93.

Morrison WH, Hamilton RJ, Kaln C (1995).Sunflower seed oil. In: Developments in Oils and Fats, (RJ Hamilton ed.), pp. 132–51. *Blackie Academic and Professional,* Glasgow.

Mourad JJ, Amodeo C, Champvallins M, Brzozowska-Villatte R, Asmar R (2017). Blood pressure-lowering efficacy and safety of perindopril/indapamide/amlodipine single-pill combination in patients with uncontrolled essential hypertension: A Multicenter, Randomized, Double-Blind, Controlled Trial. *Journal of Hypertension,* DOI: 10.1097/HJH.0000000000001359.

Nadeem M, Anjum F M, Hussain S, Khan MR, Shabbir MA (2011). Assessment of the antioxidant activity and total phenolic contents of sunflower hybrids.*PakistanJournal of Food Science* 21 (1-4): 7-12.

Pacureanu JM, Vranceanu AV, Stanciu D, Raranciuc S (1999). High oleic acid content in sunflower genotypes in relation with resistance to diseases.*Romanian Agricultural Research* 11-12: 21-27.

PacureanuJoita M, Stanciu D, Petcu E, Raranciuc S, Sorega I (2005).Sunflower genotypes with high oleic acid content. *Romanian Agricultural Research* 22: 23-26.

Salaberria F, Constenla D, Carelli AA, Carriin ME (2016).Chemical Composition and Physical Properties of High Oleic Safflower Oils (Carthamustinctorius, var. CW88-OL and CW99-OL). *Journal of the American Oil Chemists' Society* 93:1383–1391.

Singleton VL, Rossi JA (1965).Colorimetry of Total Phenols with PhosphomolybdicPhosphotungstic acid. Reagents.*American Journal of Enology and Viticulture* 16 (3): 144-158.

Tsaliki E, Lagouri V, Doxastakis G (1999). Evaluation of the antioxidant activity of lupin seed flour and derivatives (*Lupinusalbus ssp. graecus*).*Food Chemistry* 65: 71–75.