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A comparative analysis of oil content and fatty acid in different varieties of *Arachis hypogaea* L. from turkey

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Abstract

The aim of the study is to investigate the composition of the oil content and the fatty acids in different varieties (i.e. NC-7, Batem-5025, Osmaniye-2005, Sultan, and Halisbey) of peanut (Arachis hypogaea L.) grown in the province of Osmaniye in Turkey. Batem-5025 provided the greatest percentage of oil with 50.30%. Higher concentrations in oil specimens were found for oleic and linoleic acids. The fatty acids in the all varieties were oleic (51.32-62.43%), linoleic (18.27-27.54%), palmitic (8.35-9.69%), stearic (2.64-3.36%), behenic (2.56-2.85%), arachidic (1.43-1.62%), and lignoceric (1.15-1.53%) acids were listed in order of concentration. The saturated fatty acids were observed to be far less than the unsaturated ones (80.07-81.88%) in any of the varieties. The varieties of NC-7 and Osmaniye-2005 had oleic and linoleic acids at the highest concentrations and stearic and palmitic acids at the lowest, respectively. NC-7 showed the best oleic-to-linoleic (O/L) ratio with 3.41.

Key words: Peanut (Arachis hypogaea L.), fatty acids, varieties, Turkey

Introduction

Humans like tropical inhabitants have ever required nutritive Humans like tropical inhabitants have ever required nutritive edible plants in their diets including legumes and especially their seeds which contain much protein and lipid as well as fatty acids (Gaydou et. al., 1983; Ahmed and Young, 1982). Peanut, Arachis hypogaea Linn is also known as groundnut indicating seed develops underground (Nwokolo, 1996; O'brien, 2008; Akhtar et al., 2014), or rarely known as earthnut, monkeynut and goobers (Nwokolo, 1996). Its cultivation dates back to 2000 to 3000 B.C. and is originated from South America. As edible seeds of a legume (Salve and Arya, 2018; Atasie et al., 2009; Ahmed and Young, 1982), peanuts are highly nutrional and so valuable all over the world for many ages (Higgs, 2003). Dietary neccessities are majorly met by vegetable oils in a daily manner (Anyasor et al., 2009). These oils are obtained from peanuts which also provide protein for humans and even animals and then have much value for feeding the world (Nwokolo, 1996; Tai and Young 1975; Higgs, 2003; Akhtar et. al., 2014; Gulluoglu et. al., 2016). As a rich mineral source including Na, Cu, Fe, Zn, Ca, Mg and K; peanut varieties offer quality nutrition with their characteristics of full of energy with protein (25-30%), carbohydrate (9.5-19%), and oil (35-56%). This feature makes the peanut plant indispensable for mitigation of the protein-energy malnutrition (Ahmed and Young, 1982; Yav et al., 2008; Atasie et al., 2009; Ayoola and Adeyeye, 2010; Ingale and Shrivastava, 2011; Chowdhury et al., 2015; Gulluoglu et. al., 2016). In addition to protein, either human or animal diets certainly have fats and oils as key nutrients because these are bountiful sources of energy (9 cal/g) and besides can help to regulate physical systems in the body by providing essential fatty acids which are the building blocks for the required hormones and containing oil-soluble vitamins A, D, E, and K

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Our foods with oil are distinguished with texture, softness, taste and satiety (Strayer, 2006). There is plenty of oil in a typical peanut (Grosso et al., 1997; Grosso et al., 2000; Atasie et al., 2009). Peanut oil is shielded from free radicals or other damaging agents because of the ideal composition of fatty acids and antioxidants (Akhtar et. al., 2014). Several extracts from peanut seeds can facilitate medical treatments as they are antioxidative, antibacterial, antifungal and anti-inflammatory (Lopes et al., 2011). The fatty acid concentration may nutritionally enhance peanuts in addition to the advantage of storage (Gulluoglu et al., 2016). The oil quality of each peanut is based highly on its fatty acid composition (Sekhon et al., 1972). To evaluate food products in terms of shelf life, nutrition quality and flavor, the composition of fatty acid is a crucial key (Gaydou et al., 1983; Tang et al., 2013; Norden et al., 1987). For peanut products and its seeds, these criteria are also determined by the combination of fatty acids (FAs) like saturated, monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) included in peanut oil. The high oleic acid (HO) content of peanut oil is nutritionally favored for its best composition and hence so valuable for augmented thermo-oxidative stability in manufacturing as well as health concern. One of the major oilseed crops is peanut (Nawade et. al., 2018). It has been reported that peanut varieties differ significantly in saturated fatty acids contents such as palmitic, stearic, arachidic, behenic and lignoceric acids (Gulluoglu et al., 2016). Oleic, linoleic and palmitic acids were observed to be in high concentrations in peanut kernel oil (Musa, 2010). A negative correlation was found between oleic and linoleic acids (Hammond et al., 1997). The genotypes were not statistically different in the amount of crude oil contained. These fatty acids can be ranked in order of concentrations from the highest to the lowest, as follow: oleic, linoleic, palmitic, stearic and linolenic acids (Kalefetoglu Macar et. al., 2018). The fatty acids of peanut oil varieties have variations in quantity and relative proportions. Nearly 90% of total fatty acids consist of oleic, linoleic and palmitic acids, and the remaining part is stearic, arachidic, 11-eicosenoic, and behenic acids in small quantities (Bansal et. al., 1993; Ahmed and Young, 1982). Oleic acid can be defined as an omega-9 MUFA in peanut oil, and its presence gains seeds better quality with longer shelf life, higher relish, optimized composition of fatty acid, in favor of human health (Barkley et al., 2009; Gundesli et al., 2019). Linoleic acid is an omega-9 PUFA, and it has been tried to obtain low quantities (<10%) in developed peanut varieties, other than higher oleic acids (<74%) (Barkley et al., 2009). Both unsaturated fatty acids comprised approximately three fourth of the peanut oil composition (Ahmed and Young, 1982). O/L ratio increases with higher amount of oil that peanuts contain, or vice versa. Higher concentrations of oleic acid occur with less linoleic acid content (Dwivedi et al., 1993). Peanuts are more tradable thanks to health benefits when O/L ratio is higher (Andersen and Gorbet, 2002). The common ratio has mostly trended around 1.5-2.0, and the description of "high oleic-acid" in peanuts refers to what O/L ratio approximates to 9 (Davis et al., 2016). The longevity of preserving peanut oil respected as shelf-life depends on fatty acid concentrations, majorly oleic (C18:1) to linoleic (C18:2) acid (O/L ratio) (Mercer et al., 1990; Ahmed and Young, 1982; Grosso et al., 2000; Nawade et al., 2018; Bansal et al., 1993). Increasing O/L decreases the iodine value of oil, extending its shelf-life (Bansal et al., 1993). Peanut seeds are very useful as flour and oil in a variety of sectors for nutritional, medicinal and industrial purposes, providing that the standard procedures are applied with appropriate supplies. Unprocessed peanuts are most effectively used for nutritional and industrial requirements, whereas roasting process has a positive effect on the amount of mineral elements without risk of reduction and thus roasted peanuts satisfy the oil needs for prophylactic or therapeutic efforts in medicine, particularly to deal with male infertility (Ayoola and Adeyeye, 2010). MUFA concentration is high in peanut oil, known as part of a healthy diet to reduce the bad cholesterol levels (LDL) and not negatively influence the good ones (HDL) (Abrar et al., 2018). Furthermore, PUFAs and MUFAs of peanuts are able to raise the HDL levels when consumed in a diet that is of vital importance to maintain well-being with disease prevention (Chowdhury et al., 2015). In the literature, in vitro or in vivo studies propose peanut oil as an effective agent for tackling cardiovascular diseases, particularly atherosclerosis or cancer cases through several metabolisms in a body. The reason is why it contains a great amount of specific antioxidants to increase in the serum of a healthy man, other than MUFAs and PUFAs. Many trials indicated that extracted from peanut oil, polyphenols and sterols made antiproliferative and proapoptotic contributions to cell lines of prostate and breast cancer so that such conditions as cancer, diabetes, and cardiovascular diseases are more likely to be cured (Akhtar et. al., 2014). Throughout a growing season, a group of factors may influence the oil amount and fatty acid concentrations of peanut varieties, including the environmental conditions (growth habit), soil types, seed maturity, and genetic factors. The fatty acid content of peanut oil depends on growth habit (Bansal et. al., 1993; Gulluoglu et al., 2016; Ahmed and Young, 1982; Nawade et al., 2018; Grosso et al., 1994; Dwivedi et al., 1993). There is evidence that the season of produce is significantly different from and even interactive with the growing area, besides yearly variations in oil production (Holaday and Pearson, 1974).

The aim of study was to determine the oil contents and the fatty acid compositions of several peanut varieties (NC-7, Batem-5025, Osmaniye-2005, Sultan, and Halisbey) grown in Osmaniye/Turkey and harvested in the year of 2018.

Materials and Methods

We studied the seed kernels of Peanut (Arachis hypogaea L.) varieties (NC-7, Batem-5025, Osmaniye-2005, Sultan, and Halisbey). In this study, all the cultivations were made in the same year (2018) and the region (the province of Osmaniye, Turkey).

Oil extraction

To study the sample seeds were preserved under dry and cool conditions. The soxhlet extraction method was used with an automatic device to get fresh oil from peanut seeds and tubers (9 g each) in order to analyze fatty acids. The used solvent was hexane. The oil content refers to the gram weight of oil extracted from 100 g of the sample.

Determination of fatty acids

Gas chromatography (GC; Perkin Elmer, Shelton, USA) was used to profile the fatty acids included in the oils. The chromatographic column had an inner dimension of 30 m ×

0.25 mm and a film 0.25 µm thick to carry out separation using a flame ionization detector (FID). The temperatures of the oven and the injector and detector were arranged as follow. The oven has been held at 120°C for 2 min, heated at a rate of 5°C/min for 20 min and then held again at 220°C for 10 min; the injector was set at 280°C and the detector at 260°C. For the expression of the results, the GC area percent represents the mean value ± SD.

Statistical analysis

The means ± standard error (SE) were calculated from three independent experiments. The significant difference was compared by the least significant differences (LSD) test executed at 5% level of probability.

Results and Discussion

Peanut oil is one of the most valuable oils and protein sources among other plant oils worldwide (Gulluoglu et al., 2016). Peanut is characterized by its high oil content (Grosso et al., 2000; Atasie et al., 2009). The oil contents obtained from specific peanut varieties in this study varied from 46.62% (Osmaniye-2005) to 50.30% (Batem-2025) (see Table 1). Another variety (NC-7) also produced oil higher than 50%. In a study of Gulluoglu et al. (2016), the oil percentages of the peanut varieties (Halisbey, Sultan, Osmaniye-2005, NC-7 and Batem-5025) were reported as 46.22, 46.33, 49.65, 43.71 and 46.07%, respectively. The peanut kernel samples were found to contain oil in percentages varying from 35 to 56% by genotype and growing conditions such as maturity period, climatic conditions (i.e. temperatures), geographical location, growing season and so on (Holaday and Pearson, 1974; Brown et al., 1975; Raheja et al., 1987; Savage and Keenan, 1994; Hassan et al., 2005; Asibuo et al., 2008; Isleib et al., 2008). Fat-soluble vitamin absorption is so critical that the prescribed diets should have appropriate oil composition (Atasie et al., 2009). All the fatty acid profiles identified in this study based on the GC measurements. The fatty acids profile were found significantly different among varieties ($P < 0.05$)(Table 1). The nutritional value of the peanut seeds are depends on the proportions between different fatty acids as well as their longevity of shelf-life, including saturated fatty acids, MUFAs and PUFAs included in peanut oil (Gulluoglu et al., 2016; Nawade et al., 2018). MUFAs are higher in five peanut varieties. The highest PUFA value was reported in Osmaniye-2005 with 27.63%, and the lowest in NC-7 with 18.33% (Table 1). The percentage of unsaturated fatty acids (UFAs), a total of MUFAs and PUFAs, hit the peak in the NC-7 with 81.88%, followed by Batem (81.33%), Halisbey (80.65%), Osmaniye-2005 (80.15%), and the last, Sultan (80.07%). The taste and quality of peanut and its products are mainly based on the fatty acid composition of peanut seeds (Andersen and Gorbet, 2002).

Peanut kernel oils contain primarily oleic, linoleic and palmitic acids (Musa, 2010; Grosso et al., 2000). It was reported that oleic, linoleic and palmitic acids comprised 88.78%, on average, of the total fatty acids contained in the studied varieties. Several authors published similar results (Bansal et. al., 1993; Ahmet and Young, 1982; Gulluoglu et al., 2016; Ozcan and Seven, 2003). Hammond et al., (1997) have been reported that there is a negative correlation between the major fatty acids, oleic and linoleic. The most valuable peanut oil is the high oleic (HO) one, which is favourably nutritional for human health and augmented thermos-oxidative stability in manufacturing (Nawade et al., 2018). The oil content in peanut seeds consists of nearly 80% of unsaturated fatty acids, whose percentage of oleic acids are 51.32 to 62.43% higher than that of linoleic acids in the range of 27.54 to 18.27%. These results are significantly indifferent from the literature (Pearce and Samad, 1980; Branch et al., 1990; Bansal et al., 1993; Dwivedi et al., 1993; Grosso et al., 1994; Asibuo et al., 2008; Barkley et al., 2009). The peanut varieties can be ranked from 80.93% (Sultan) to 78.86% (Osmaniye-2005) of the total fatty acids in order of oleic and linoleic acid contents. The peanut variety of NC-7 produces the highest relative amount of oleic acid as percentage of 62.43% while Osmaniye-2005 contains the lowest value of 51.32%. In another study of Gulluoglu et al. (2016) it was reported that the oleic acids of peanut varieties NC-7, Batem-5025, Sultan, Halisbey, and Osmaniye-2005 comprises 57.40, 57.29, 53.23, 52.16, and 48.81% of total fat, respectively. Moreover, the peanut varieties varied from 18.27% (NC-7) to 27.54% (Osmaniye-2005) by the linoleic acid content. Similar findings have already been reported by Gulluoglu et al. (2016). The recent studies have mainly purposed to value peanut oil with cultivating new peanut lines by increasing oleic acid and necessarily decreasing linoleic acid in their content for health and industrial concern (Nawade et al., 2018). In the current study, approximately 90% of total fatty acids in the oil composition of all the varieties studied accounts for oleic, linoleic and palmitic acids. The results are parallel with the study of Kalefetoglu Macar et al. (2018). By O/L ratio, the peanut varieties ranked from 1.86 to 3.41. The highest ratios are in NC-7 (3.41) and Batem-5025 (3.03). It has been determined that the relative proportion of oleic and linoleic acid of the peanut varieties depends on the environmental factors at the growing season (Gulluoglu et al., 2016). Higher ratio of O/L may lead to very longer shelf life (Mercer et. al., 1990; Ahmed and Young, 1982; Grosso et al., 2000; Bansal et al., 1993). Thus, NC-7 and Batem 5025 varieties are important materials among the analyzed varieties in terms of shelf life.

The peanut economy has widely experienced HO varieties in recent times for higher storage quality than traditional ones. When O/L ratio is equal to or exceeds 9, the variety is normally categorized under HO peanuts, whereas the most conventional varieties can reach only up to 1.5-2.0 (Davis et al., 2016). However, this study showed that two varieties (NC-7 and Batem 5025) from Osmaniye/Turkey had higher O/L content than varieties from previous studies. The content of saturated fatty acids (palmitic, stearic, arachidic, behenic, and lignoceric acids) had statistically significant variations among the analyzed peanut varieties (Table 1).

Table 1 ranks the peanut varieties by specific acid content from the lowest to the highest values as follows: 8.35 to 9.69% for palmitic acid, 2.64 to 3.36% for stearic acid, 1.43 to 1.62% for arachidic acid, 2.56 to 2.85% for behenic acid, and 1.15 to 1.53% for lignoceric acid. Out of the saturated fatty acids, palmitic acid had the highest percentage for all the peanut varieties (Sogut et al., 2016; Gulluoglu et al., 2016).

Table 1: Fatty acid profile (%), and the O/L calculations.

Compound	Fatty Acid	Name of Varieties					
		NC-7	BATEM-5025	OSMANİYE-2005	SULTAN	HALISBEY	**LSD**
Total fat (g/100g)		50.16	50.30	46.62	48.20	47.90	
Palmitic Acid	(C16:0)	8.35±0.24^{d}	8.69±0.25^{c}	9.64±0.07^{a}	9.52±0.07^{b}	9.69±0.07^{a}	0.074**
Palmitoleic Acid	(C16:1)	0.07±0.003^{a}	0.07±0.003^{a}	0.06±0.002^{b}	0.06±0.002^{b}	0.07±0.003^{a}	0.006*
Stearic Acid	(C18:0)	3.26±0.09^{b}	3.36±0.10^{a}	2.64±0.08^{e}	3.17±0.09^{c}	2.78±0.08^{d}	0.018**
Oleic Acid	(C18:1n9c)	62.43±0.46^{a}	60.25±0.44^{b}	51.32±0.38^{e}	52.91±0.39^{c}	52.42±0.39^{d}	0.241**
Linoleic Acid	(C18:2n6c)	18.27±0.14^{e}	19.87±0.15^{d}	27.54±0.21^{a}	26.02±0.19^{c}	27.04±0.20^{b}	0.124**
α-Linolenik Acid	(C18:3n3)	0.03±0.001^{c}	0.03±0.001^{c}	0.05±0.002^{a}	0.04±0.002^{b}	0.05±0.002^{a}	0.009**
Arachidic Acid	(C20:0)	1.62±0.06^{a}	1.59±0.05^{a}	1.44±0.04^{b}	1.59±0.05^{a}	1.43±0.04^{b}	0.036**
Eicosenoic Acid	(C20:1n9c)	0.99±0.04^{b}	0.92±0.03^{c}	1.04±0.03^{a}	0.92±0.03^{c}	0.98±0.04^{b}	0.024**
Behenic Acid	(C22:0)	2.56±0.07^{c}	2.67±0.08^{b}	2.85±0.08^{a}	2.78±0.08^{a}	2.57±0.07^{c}	0.045**
Arachidonoic Acid	(C20:4n6)	0.03±0.001	0.14±0.005	0.04±0.001	0.04±0.001	0.04±0.001	NS
Erusic Acid	(C22:1n9)	0.06±0.002	0.05±0.002	0.10±0.004	0.07±0.003	0.05±0.002	NS
Tricosanoic Acid	(C23:0)	0.05±0.002	0.16±0.01	0.12±0.004	0.13±0.005	0.07±0.003	NS
Lignoceric Acid	(C24:0)	1.15±0.03^{e}	1.19±0.03^{d}	1.53±0.06^{a}	1.34±0.05^{c}	1.43±0.04^{b}	0.009**
Miristic Acid	(C14:0)	0.04±0.00^{a}	0.02±0.00^{c}	0.04±0.00^{a}	0.03±0.00^{b}	0.04±0.00^{a}	0
Heptadecanoic Acid	(C17:0)	0.10±0.00^{a}	0.09±0.00^{b}	0.08±0.00^{c}	0.09±0.00^{b}	0.07±0.00^{d}	0
O/L		3.41	3.03	1.86	2.03	1.93	
ΣSFA		17.13	17.77	18.34	18.65	18.08	
ΣMUFA		63.55	61.29	52.52	53.96	53.52	
ΣPUFA		18.33	20.04	27.63	26.11	27.13	
ΣUFA		81.88	81.33	80.15	80.07	80.65	

Different letters stated in the same row are statistically important. N.S: non-significant, *, p<0.05; **p>0.01.
SFA: Saturated Fatty Acid, MUFA: Mono Unsaturated Fatty Acid, PUFA: Poly Unsaturated Fatty Acid, UFA: Unsaturated Fatty Acid

Conclusion

In this study, the unsaturated fatty acids in the extracted oil from the studied peanut (*Arachis hypogaea* L.) varieties (NC-7, Batem-5025, Osmaniye-2005, Sultan and Halisbey) were found to be much higher than the saturated fatty acids. The highest ratio of oleic to linoleic (O/L) was observed in the variety of NC-7 and Batem 5025. Furthermore, the seed kernels of the sample varieties produced higher content of monounsaturated fatty acids (MUFAs). The obtained results in this study are essential to assist the researchers and the manufacturers in future works regarding the peanut plant.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

Z.E. and M.Z. contributed equally to this manuscript. The authors contributed to the discussion of the results and all of them read and approved the final manuscript.

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