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AN INVESTIGATION OF FREQUENTLY CONSUMED EDIBLE OILS IN TURKEY IN TERMS OF OMEGA FATTY ACIDS

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The fatty acid profiles of frequently consumed oils and crops cultivated in Turkey were investigated in regard to omega fatty acids. Analyses were carried out on commercially sold oils, sunflower, olive, and fish oils, and oils extracted from fatty seeds of hazelnut, walnut, olive, sunflower, poppy, sesame, and pumpkin, and butter produced in Turkey. Hazelnut and olive oils were found to be rich in omega-9 (oleic acid 18:1), walnut, poppy seed, sesame, and pumpkin seed were rich in omega-6 (linoleic acid 18:2), and butter was rich in short chain fatty acids and omega-9. Fish oil, from mackerel, was the richest in omega-3 fatty acids and fatty acid diversity. There were some alterations between commercially sold oils and oils extracted from seeds in regard to fatty acid percentages and variety.

Keywords: fatty acid, hazelnut, GC-MS, Turkish crops, omega fatty acid.

Being one of the three basic food components, fats supply most of the human body′s energy needs and have physiological and biosynthetic functions [1, 2]. The human body requires the uptake of two important fatty acids, linoleic acid (18:2, ω6) and α-linolenic acid (18:3, ω3), known as essential fatty acids (EFA). The term essential means that these fatty acids must be supplied from diet because the body needs them but cannot synthesize them. Humans actually lack the enzymes that introduce double bonds at carbon atoms beyond the carbon-9 in the fatty acid chain [1]. Since ω3 fatty acids are relatively limited in the diet, it is easier to see beneficial effects from their supplementation. EFAs are used in several physiological processes such as inhibition of tumor development and tumor metastasis, lowering cholesterol levels, reducing the risk of development of atherosclerosis, modifying platelet and vascular function, treating heart disease, improving arthritis, relieving allergic symptoms, eczema, and psoriasis, diminishing the inflammatory response, and modulating the immune system [3–6]. The fatty acids are also important for children′s diet in improving the nervous system and mentality [2]. It has been proved in the conducted studies that the Mediterranean diet, also known as a diet rich in monounsaturated ω3 and ω6 fatty acids, reduces the risks of cardiovascular diseases and heart attacks; therefore, Mediterranean people are said to live longer [7].

In Turkey, which is an agricultural paradise, many kinds and species of fatty seed products are produced and used. Turkey ranks first in hazelnut production and the fourth in olive production in the world [8]. The annual oil consumption is around 20–25 kg per person in Turkey, and human diets are rich in fat from various sources, including sunflower, olive, corn, cotton, and butter. Sunflower oil is the most consumed vegetable oil in Turkey. Rapeseed and soybean oils have the potential to help consumers achieve dietary requirements, though they are also used for biodiesel production.

The main aim of our study was to analyze the omega fatty acid compositions of the frequently consumed oils and crops cultivated in Turkey. We have also compared the fatty acid profiles of commercially sold oils and those of fatty seeds extracted in our laboratory by Soxhlet extraction. For this purpose, oils of hazelnut, walnut, olive, sunflower seeds, poppy seed, sesame, pumpkin seeds, butter, and fish were extracted and analyzed. The commercially sold ones (sunflower oil, olive oil, fish oil and butter) were purchased from local markets and examined.

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TABLE 1. Fatty Acid Contents of Frequently Consumed Oils and Crops Cultivated in Turkey

Compound	RI	Hazelnut				
		cakildak	fosa	mincane	giresun yaglisi	palaz
14:0	1758	0.12 ± 0.04	0.12 ± 0.04	0.12 ± 0.04	0.12 ± 0.04	0.11 ± 0.04
16:1 Δ^9	1935	0.33 ± 0.09	0.50 ± 0.84	0.30 ± 0.08	0.40 ± 0.08	0.51 ± 0.08
16:0	1968	8.50 ± 0.82	8.50 ± 0.80	7.45 ± 0.7	7.12 ± 0.7	5.42 ± 1.01
18:0	2190	5.14 ± 0.80	3.81 ± 0.74	4.52 ± 0.8	5.65 ± 0.3	5.50 ± 0.40
18:1 Δ^9	2133	84.05 ± 2.20	84.01 ± 1.60	85.01 ± 4.11	83.02 ± 1.6	85.2 ± 2.80
18:2 $\Delta^{9,12}$	2145	1.52 ± 0.45	2.10 ± 0.10	1.82 ± 0.08	3.22 ± 0.08	2.52 ± 0.22
20:0		0.11 ± 0.01	0.12 ± 0.03	0.54 ± 0.21	0.44 ± 0.07	0.63 ± 0.01

Compound	RI	Walnut		Pumpkin seed	Poppy
		Gumushane	Sebinkarahisar		
14:0	1758	0.12 ± 0.04	0.13 ± 0.03	1.52 ± 0.01	2.21 ± 0.01
16:1 Δ^9	1935	0.25 ± 0.04	0.23 ± 0.02	2.11 ± 0.12	3.12 ± 0.02
16:0	1968	6.71 ± 0.45	5.40 ± 0.08	7.22 ± 0.23	10.70 ± 0.02
17:0	2054				1.34 ± 0.01
18:0	2190	1.52 ± 0.2	1.12 ± 0.14	27.03 ± 1.52	11.10 ± 0.01
18:1 Δ^9	2133	10.54 ± 0.5	10.40 ± 0.32	17.04 ± 0.92	2.45 ± 0.61
18:2 $\Delta^{9,12}$	2145	71.05 ± 2.9	72.06 ± 2.10	45.02 ± 2.12	66.06 ± 1.6
18:3 $\Delta^{9,12,15}$	2100	9.60 ± 0.23	10.50 ± 1.10		2.10 ± 0.02

RI: retention time.

The fatty acid compositions of frequently consumed commercial oils and oils from the crops cultivated in Turkey are presented in Tables 1 and 2. The seeds highest in fat content were hazelnut (67–71%), walnut (71%), sunflower (67%), sesame (65%), and pumpkin (45%), and the oil contents of poppy (25%) and olive (21%) were at moderate levels.

With its 15–20 varieties of hazelnut, Turkey is considered the main producer and exporter of hazelnut, responsible for 65% of the world′s total production [9]. The majority of cultivated hazelnut is consumed especially as appetizers, and the remaining part is used in oil production. Found in many different foods, oleic acid (18:1, ω9) with a percentage of approximately 85 was the predominant fatty acid in hazelnut varieties of the Eastern Black Sea Region. Palmitic (16:0) and stearic acids (18:0) were the next most abundant fatty acids with a percentage of around 12. α-Linoleic acid (18:2, ω6) was present in amounts of 1.5–3.0%, whereas α-linolenic acid (18:3, ω3) was not detected. There were no significant differences ($p > 0.05$) among the five hazelnut varieties in terms of fatty acid composition and proportion. According to a literature report, oleic acid in Turkish hazelnuts is found between 75–82% and linoleic acid between 10–12%, but α-linolenic has not been detected [10]. It is reported that the oleic, linoleic, and α-linolenic acid contents of two different hazelnut varieties (tombul and imperial cultivars) were 74–76%, 14.52–17.78%, and 0.11–0.13%, respectively [11]. It is seen that the fatty acid profiles of hazelnuts that we examined show parallelism with those obtained by other researchers. However, we did not find ω3 fatty acid in the samples. Studies suggest that in the consumption of a meal enriched with higher levels of monounsaturated fatty acids, more beneficial chylomicrons are secreted and rapidly cleared [12]. Walnuts are an important source of various antioxidants, L-arginine, and energy-containing oil (70%) [13]. Recent reports reveal a negative correlation between walnut consumption and reduced cholesterol, low risk of coronary heart disease, and diabetes [14]. The walnut samples tested had similar fatty acid compositions ($p < 0.05$). The major fatty acids of walnut were linoleic (71%), α-linolenic (10%), and oleic acid (10%). Similarly, another study reported that linoleic acid (60%) was the major fatty acid of walnut [15].

Sesame (*Sesamum indicum* L.) is one of the world′s most important and oldest oil seed crops known to man. Roasted and unroasted sesame seed oils are widely used in Turkey. We found that linoleic acid was the main fatty acid (58%), and the rest of the fatty acids were oleic, stearic, palmitic, and palmitoleic acids. Similar to our results, it was previously reported that ω6 fatty acid (linoleic acid) was dominant in sesame [16]. The oxidative stability of sesame oil is superior to that of other vegetable oils, although it contains nearly 85% unsaturated fatty acids [17].

Oleic acid constituted 72% to 84% of the fatty acids in both commercially sold olive oil and in the oil extracted from olive (*Olea europaea*). Linoleic, palmitic, and stearic acids were also found in small amounts in both olive oil (O1 and O2) samples. Our results were similar to those found in the literature [12, 18, 19]. On the other hand, the extracted olive oil was interestingly richer than commercial olive oil in terms of fatty acid diversity, especially in terms of palmitic, palmitoleic, and long-chain saturated fatty acids.

TABLE 2. Fatty Acid Contents of Frequently Consumed Oils and Crops Cultivated in Turkey

Compound	Sesame	Butter	Sunflower		Olive		Fish oil	
			natural	commercial	natural	commercial	natural	commercial
4:0		4.50 ± 0.20						
8:0		2.22 ± 0.12						
10:0		6.01 ± 0.05						
12:0		8.61 ± 0.51						
14:0	3.13 ± 0.11	16.44 ± 0.54					8.50 ± 0.68	7.42 ± 0.25
15:0		2.90 ± 0.01					0.71 ± 0.12	3.01 ± 0.14
16:1 Δ^{9}	4.21 ± 0.10				1.43 ± 0.10		5.51 ± 0.24	9.50 ± 0.78
16:0	5.52 ± 0.5	19.22 ± 1.23	6.45 ± 0.03	7.82 ± 0.14	14.02 ± 1.10		17.02 ± 0.82	19.91 ± 1.36
17:0	1.60 ± 0.01	2.14 ± 0.04						
18:0	7.51 ± 0.07			0.25 ± 0.04	6.61 ± 0.10	5.12 ± 0.12	2.32 ± 0.45	2.22 ± 0.05
18:1 Δ^{9}	17.04 ± 1.4	32.05 ± 2.05		10.30 ± 0.08	72.30 ± 1.85	85.01 ±	22.05 ± 0.14	24.50 ± 2.23
18:2 $\Delta^{9,12}$	58.04 ± 2.4		90.56 ± 2.40	78.05 ± 1.90	2.22 ± 0.12	1.68	7.02 ± 0.12	1.32 ± 0.24
18:3 $\Delta^{9,12,15}$	2.45 ± 0.01					9.11 ± 0.08	7.70 ± 0.51	6.60 ± 0.56
20:0			1.05 ± 0.10		0.42 ± 0.12		1.30 ± 0.12	9.80 ± 0.84
20:1 Δ^{11}					2.50 ± 0.15		8.51 ± 0.54	
20: 4 $\Delta^{5,8,11,14}$							8.23 ± 0.52	9.21 ± 0.56
20:5 $\Delta^{5,8,11,14,17}$							8.25 ± 0.52	4.26 ± 0.29
22:0			1.28 ± 0.10	0.25 ± 0.01	0.51 ± 0.12			
22:6 $\Delta^{4,7,10,13,16,19}$							2.70 ± 0.31	1.95 ± 0.56
Phytol		2.55 ± 0.11						
Cholesterol		2.65 ± 0.11						

Pumpkin seeds are generally dried and consumed as snacks. The oil content of pumpkin seed was 50%, and the major fatty acid was linoleic acid (45%). The rest of the other fatty acids of pumpkin seeds were oleic (18:1), stearic (18:0), and linoleic (18:2) acids. It was determined that the fatty acid composition of pumpkin seeds is as follows: α-linoleic (55.6%), oleic (20.4%), palmitic (13.4%), stearic (9.96%), and myristic (0.17%). There are some differences between our findings and the literature data [20]. This may be due to growing conditions such as soil, climate, etc.

Poppy seeds do not contain alkaloids. Alkaloid synthesis starts during germination. Cultivation of opium poppy is restricted by the government because of its potential consumption as a narcotic. In the districts where poppy cultivation is allowed, poppy seed is an important income source, and it is generally used as a foodstuff [21]. The fat content of poppy seed is 40% and the main component of poppy oil is linoleic acid (66%). Linoleic acid (52–71%) has been reported as the most abundant fatty acid in poppy seeds collected from seven regions, and the level of α-linolenic acid is low (2.10%) [22].

Sunflower oil is used in cooking, prevalently in Turkey. In the current study, linoleic acid was the main fatty acid in both sunflower oil supplied from markets and that obtained in our study by extraction. However, the linoleic acid percentages of commercial and extracted oils were significantly different ($p < 0.05$).

In Turkey, butter is the most widely consumed animal fat. The composition of butter shows variations depending on the plant flora where the butter is produced [23, 24]. Homemade butter had 40% short chain fatty acid (C4–C14), the major fatty acids were palmitic and oleic acids, and the other major components were phytol and sterol. Phytol is a long-chain diterpene alcohol formed by the decomposition of chlorophyll, vitamin E, and vitamin K. Cholesterol is a sterol and one of the animal lipids and plays a role in steroid synthesis as a starting compound and in the regulation of fluidity of the plasma membrane [25].

The major fatty acids in both fish oils are oleic acid. Of all the oils analyzed, fish oils are the richest in terms of fatty acid diversity and polyunsaturated fatty acids (PUFA). Oleic acid (18:1) is the most abundant fatty acid in the fish oils. α-Linolenic (18:3), linoleic (18:2), arachidonic (20:4), eicosapentaenoic (20:5), and docosahexaenoic (22:6) acids were determined in the fish oils. Omega-3 makes up almost 17% of the fatty acids in both commercially sold fish oil and oil extracted from fish (*Scomber scombrus*). PUFA mainly from the ω3 series are now well known as essential lipids of major interest in human health and nutrition, and fish oils represent the main marine source. It is reported that these fatty acids reduce the risk of cancer, cardiovascular diseases, etc. [25–27].

The major findings of the fatty acid compositions of the tested samples are as follows: 1) oleic and linoleic acids are the most abundant fatty acids determined in the samples; 2) hazelnut samples are rich in monounsaturated fatty acid, and there was no significant difference among different species; 3) omega-6 fatty acid, one of the essential fatty acids, is found in the highest proportion in sunflower, walnut, poppy, and sesame oils; 4) α-linolenic acid (18:3) is highest in walnut (approximately, 10%) and fish (8%), followed by sesame and poppy seeds in descending order of abundance; 5) butter and fish oils are the richest in regard to fatty acid diversity, and the amount of short-chain fatty acid is highest in butter; 6) fish oil is rich in PUFA and ω3 fatty acids; 7) hazelnut oil shows a similarity to olive oil in terms of oleic and many fatty acids; 8) fatty acid types of commercial and extracted oils are similar, but there were significant differences in their percentages.

EXPERIMENTAL

Chemicals. Analytical grade *n*-hexane, methanol, sodium chloride, anhydrous sodium sulfate, and boron trifloride were obtained from Sigma-Aldrich Chemie GmbH (Germany) and Merck (Darmstadt, Germany).

Samples. Two species of walnut, olive, sunflower, poppy seeds, sesame, and pumpkin samples used in this study were collected as organic products from a farmer, and a homemade butter from cow′s milk was obtained from a local dairy product store. The fish oil was extracted from meat of mackerel (*Scomber scombrus*). Five species of hazelnuts (*Corylus avellane* L.) (cakildak, fosa, mincane, giresun, and palaz) were supplied by the Hazelnut Research Institute (2006 harvest season; Giresun, Turkey). The commercial oils of sunflower, olive, and fish were obtained from markets and a pharmacy. Samples of the seeds were dried in an oven at 40°C to constant weight and ground by a grinder. Total oils were extracted with *n*-hexane (60°C) using a Soxhlet apparatus. The solvent was removed by a rotary evaporator (IKA® Werke GmbH & KG). The oil was weighed and stored at 4°C.

Preparation of Fatty Acid Methyl Esters. Methylation was carried out according to the procedure of Slover and Lanza [28]. The crude oil (200 mg) was saponified with 3 mL sodium hydroxide in methanol at 100°C in an oven for 10 min. Then the solution was cooled to room temperature, and 2 mL of 12% (w/v) boron trifloride in methanol was added. The solution was heated at 100°C for 10 min. After cooling, 1 mL of hexane was added and the mixture was shaken; then 1 mL of 0.6% sodium chloride was added. The organic layer was transferred, dried with anhydrous sodium sulfate, and used for chromatographic analyses.

Fatty acid methyl esters (FAME) were analyzed using gas chromatography with a flame ionization detector (FID). Gas chromatography-mass spectrometry (GC-MS) analyses were performed using an Agilent 6890 GC system equipped with an Agilent 5973 MS system (Agilent Technologies, Palo Alto, CA, USA). The mass spectrometer with an ion trap detector was used in the full scan mode under electron impact ionization (70 eV). The chromatographic column used for the analyses was an HP-5 capillary column (30 m × 0.32 mm i.d., film thickness 0.25 μm). Helium was used as the carrier gas at a flow rate of 1 mL/min. The injections were performed in the splitless mode at 230°C. One μL sample was injected and analyzed with the column held initially at 60°C for 2 min, then increased to 260°C with a 5°C per minute heating ramp, and subsequently kept at 260°C for 13 min.

Statistical Analysis. All analyses were conducted in triplicate for each sample. The results were expressed as mean ± S.D. Statistical analyses were performed using the Kruskall-Wallis test with the level of significance $p < 0.05$.

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