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A COMPARATIVE STUDY OF FATTY ACID EXTRACTION METHODS OF SESAME (*Sesamum indicum* L.) VARIETIES GROWN UNDER MEDITERRANEAN ENVIRONMENT

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KEYWORDS

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Cold Press

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Fatty Acid

ABSTRACT

Present study was carried out to determine the effects of two oil extraction methods on the composition of oil fatty acid in sesame of some Turkish genotypes. Two oil extraction techniques viz. Cold pressing (CP) and Soxhlet extraction (SE), were compared for the fatty acid composition of 25 Turkish sesame genotype. Higher averaged sesame seed oil yield (54.7%) was obtained in the SE method than the CP method (31.1%). The oil compositions of sesame genotypes were compared and the presence of five main dominated sesame fatty acid components namely palmitic, stearic, arachidic, oleic and linoleic acid was reported. Among these five fatty acid, palmitic (9.38-10.56%) and stearic acids (4.73-5.12%) were reported predominant saturated fatty acids while arachidic acid was reported in minimum concentration in sesame oil ranging of 0.52 to 0.59 %. Oleic and linoleic acids are the major fatty acids of sesame oil and are reported in large amounts in the oils of all genotypes. The percentage of oleic acid ranged from 37.15 to 41.67, while this percentage was reported between 42.22 to 45.54 for Linoleic acid. From the results of this study, it can be concluded that the fatty acid profile of the sesame oil was not significantly influenced by oil extraction method.

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1 Introduction

Sesame (*Sesamum indicum* L.), one of the oldest and very important oil seed crops known, is widely grown in tropical and subtropical areas of the World. Sesame is under cultivation for about 6000 years (Namiki, 1995). Sesame is an excellent source of oil (50%) and protein (20%) and is widely used as vegetable oil. In sesame, oleic and linoleic acids are the predominant fatty acids and constitutes more than 80% of the total oil. The high levels of monounsaturated and polyunsaturated fatty acids (MUFA & PUFA) increase the quality of the oil for human consumption. Moreover, high levels of linoleic acid, MUFA & PUFA reduce blood cholesterol and play an important role in preventing atherosclerosis (Ghafoorunissa, 1994). Oils with a high content of unsaturated fatty acids are generally more susceptible to oxidation, undergoing rapid degradation and polymerization by free radical mechanisms (Guillen & Goicoechea, 2008). But, sesame oil has a privilege characteristic such as the presence of the natural antioxidants sesamol, sesamol, and gamma-tocopherol, which gives it high oxidative stability (Corso et al., 2010).

Martin & Leonard (1964) reported that sesame is mostly used for edible purposes such as oil and confectionery. It is also used for various other purposes i.e. manufacture of margarine, soap, paint, perfumes, cosmetics, pharmaceutical products, paints and insecticides and cookies (AlamSarkar et al., 2007). Further, Weiss (2000) suggested that sesame seed contains essential amino and fatty acids specially linoleic acid. It is a good source of vitamins such as vitamin E and minerals such as calcium and phosphorus and the seed cake is also an important nutritious livestock feed. Sesame seed also contains a group of compounds called lignans which have many health promoting effects (Pathak et al., 2014).

At industrial level, oil extraction is mainly carried out by two methods, viz. cold pressing and solvent extraction (Soxhlet method). Soxhlet method involving the use of *n*-hexane or petroleum ether as extraction solvent, although gives higher oil yield but higher temperature employed in this method may cause some undesirable effects on the quality of oil (Nadeem et al., 2015). Although, cold pressing method of oil extraction gave lower oil yield but mild operational temperature conditions maintain the safety of product quality (Bavec et al., 2007). Cold pressed oils generally exceed refined oils in their nutritional value.

It maintains natural beneficial ingredients of sesame oil such as tocopherols, sterols, carotenoids, and phospholipids which are partially removed as a result of oil refining (Gogolewski et al., 2000; Koski et al., 2003). Considering the growing concern and demand about the functional and nutritional properties of oils, the present work was therefore designed to evaluate and compare the fatty acid composition of oil extraction methods of some Turkish sesame genotypes.

2 Materials and Methods

The experiment was conducted at Adana province of Turkey (35°18' E latitude, 37° 01' N longitude, and 23 m above sea level) in 2012. Seeds of 25 sesame genotypes viz. 1) Cumhuriyet-99, 2) Tan-99, 3) Kepsut-99, 4) Baydar-2001, 5) Muganlı-57, 6) Orhangazi-99, 7) Gölarmara, 8) Osmanlı-99, 9) Şanlıurfa-Siverek, 10) Diyarbakır-Merkez, 11) Kahramanmaraş, 12) Diyarbakır-Lice, 13) Adana-Kozan-2, 14) Manisa-Salihli, 15) Manisa-Alaşehir, 16) Adana-Ceyhan, 17) Antalya-Kumluca, 18) Adana-Yumurtalık, 19) Osmaniye-Kadirli, 20) Muğla-Fethiye, 21) Adana-Karataş, 22) Adana-Sarıçam, 23) Balıkesir-Ayvalık, 24) Aydın-Merkez and 25) Adana-Merkez were sown in the second week of June, 2012. The accessions were grown in four row plots of 5 m row length with a row spacing of 70 cm and intra-row spacing of 15 cm. Thinning was carried out after 25 days of sowing to secure one plant at 15 cm. Sprinkler irrigation was established immediately after sowing and thereafter used when necessary based on soil and plant conditions. Nitrogen, phosphorus and potassium were applied at a rate of 60 kg per hectare at sowing as a complete fertilizer. Weeding was carried out by hand weeding and no herbicides were applied during the growing seasons. All the plants were harvested in the last week of September, 2012.

2.1. Extraction of sesame seed oil

Sesame seeds were pressed by screw press with a nozzle diameter of 6.8 mm and a rotational speed of 47 rpm. Three replications were performed for each sample, and oil yield was calculated as percentage in weight basis. Sesame seeds were also extracted by Soxhlet apparatus to assess the total oil yield. The data were calculated as a mean of three replications. Then the two methods were compared upon the oil yield and oil composition.

2.2. Gas chromatography (GC) Analyses

An oil sample of 500 mg was dissolved in 2 ml isooctane followed by 1.5 ml of 0.5 M methanolic NaOH. The tube was then vortexed and held in boiled water for 7 min and left to cool. Then 2 ml of BF₃ (Boron trifluoride) was added, vortexed, and held in boiling water for 5 min and left to cool. After adding 5 ml NaCl the tube was vortexed. After centrifugation at 4,000 rpm for 10 min, the top layer was gathered for GC analyses (AOAC, 1984; Ozogul et al., 2011).

The fatty acid (FA) composition was analyzed by GC Clarus 500 with auto sampler (Perkin Elmer, USA) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m • 0.32 mm, ID • 0.25 µm, BP20 0.25 µm, USA). The oven temperature was brought to 140°C for 5 minutes, then raised to 200°C at a rate of 4°C/min and to 220°C at a rate of 1°C/min, while the injector and the detector temperatures were set at 220°C and 280°C, respectively.

Table 1 Comparison of oil content (%) of Soxhlet extracted and Cold pressed in Turkish sesame genotypes

Genotypes	Soxhlet	Cold Press	Differences
Cumhuriyet-99	47.9	36.4	11.6
Tan-99	53.8	38.9	14.8
Kepsut-99	48.3	40.2	8.1
Baydar-2001	49	33.6	15.3
Muganlı-57	51.3	38.2	13.1
Orhangazi-99	53.3	39.3	14
Gölmarmara	53.4	40.3	13.2
Osmanlı-99	52.5	37.1	15.4
Şanlıurfa-Siverek	52.4	31.1	21.3
Diyarbakır-Merkez	53.1	37.5	15.6
Kahramanmaraş	53	38.7	14.3
Diyarbakır-Lice	53.9	36.1	17.8
Adana-Kozan-2	52.9	42.8	10.2
Manisa-Salihli	52	34.9	17
Manisa-Alaşehir	52.4	39.6	12.9
Adana-Ceyhan	53.7	33.7	20
Antalya-Kumluca	52.8	38.4	14.3
Adana-Yumurtalık	50.9	36.5	14.4
Osmaniye-Kadirli	52.4	40.7	11.8
Muğla-Fethiye	51.2	39.3	12
Adana-Karataş	52.7	41.7	11
Adana-Sarıçam	53.6	40.6	13
Balıkesir-Ayvalık	52.4	34.7	17.7
Aydın-Merkez	54.7	37.2	17.6
Adana- Merkez	51.4	37.5	14

The sample size was 2 µl, and the carrier gas was controlled at 16 psi. The split used was 1:100. FAs were identified by comparing the retention times of FAME with a standard 37 component FAME mixture (Supelco). Three replicate GC analyses were performed, and the results were expressed in GC area percentage as a mean value. Statistical analysis was performed using SPSS by One-Way ANOVA method.

3 Results and Discussion

The results about the oil components of studied sesame genotypes revealed its dependency on the oil extraction method (Table 1). The observed variability of the seed oil content, expectedly, the averaged oil content of sesame seeds from 25 sesame genotypes was higher (average 52.2%) with Soxhlet method compared with cold pressing (average 37.8%). Oil contents of sesame varieties ranged from 47.9-54.7% in Soxhlet method and from 31.1-42.8% in cold press method. In this manner, results of this study are similar to the findings of Uzun et al. (2008) who reported oil content of 103 Turkish sesame landraces ranged from 41.2-62.7%. Similar results were reported by Asghar & Majeed (2013) and Nzikou et al. (2009). It was also reported that oil content of different sesame cultivars ranged from 50 to 69.03%, with an average of 59.5% (Abdullahi et al., 1991).

In Soxhlet method, the highest and the lowest oil percentages (54.7%, 47.9%) were obtained from Aydın-Merkez and Cumhuriyet-99 genotypes, respectively. Baydar et al. (1999) observed higher average oil content (63.25%) in Turkish sesame cultivars. Variation in oil content can be attributed either to varietal factor, environmental factor, or interaction of both factors. It is reported that Moroccan sesame cultivars contained high oil percentages (over 50%) which is a desirable trait for breeding programs to improve sesame cultivars (EL Harfi et al., 2015). Water (Alpaslan et al., 2001) and temperature also influenced the oil content of sesame (Rondanini et al., 2003). Another studies revealed that oil content was influenced under different conditions in different crops (EL Sabagh et al., 2015, EL Sabagh et al., 2016; Gulluoglu et al., 2016).

In the cold press extraction method, variety Adana-Kozan-2 was one with highest oil content among the studied genotypes. It was found that petroleum ether is a better extraction solvent (Lu et al., 2007), could be due to contributed increasing the solubilization of compounds with oxidant principles. The oxidative stability of the oil was high; it could be attributed to the presence of tocopherols, which inhibit lipid peroxidation, and of endogenous antioxidants such as sesamin and sesamol, better known as lignans (Hemalatha, 2007).

Table 2 Comparison of fatty acid composition (g/100g) of soxhlet extracted and cold pressed in sesame genotypes

Genotypes	Palmitic Acid		Stearic Acid		Arachidic Acid		Oleic Acid		Linoleic Acid	
	Soxhlet	CP	Soxhlet	CP	Soxhlet	CP	Soxhlet	CP	Soxhlet	CP
Cumhuriyet-99	9.816	10.152	4.948	4.885	0.577	0.553	39.021	39.202	43.819	43.414
Tan-99	9.633	10.076	4.945	4.847	0.584	0.550	39.183	39.456	43.762	43.203
Kepsut-99	9.399	9.603	5.128	5.073	0.591	0.572	40.053	40.223	43.033	42.765
Baydar-2001	9.660	10.160	4.816	4.692	0.523	0.521	37.847	37.936	45.295	44.811
Muganlı-57	9.722	10.087	4.882	4.805	0.555	0.548	38.376	38.821	44.635	43.919
Orhangazi-99	9.554	9.746	4.755	4.703	0.551	0.538	39.043	39.287	44.225	43.872
Gölmarmara	9.493	9.849	5.044	4.949	0.586	0.580	38.794	38.919	44.244	43.862
Osmanlı-99	9.554	9.746	4.755	4.703	0.551	0.538	39.043	39.287	44.225	43.872
Şanlıurfa-Siverek	9.504	9.894	5.120	5.042	0.606	0.594	39.317	39.622	43.597	43.057
Diyarbakır-Merkez	9.379	9.726	4.978	4.843	0.584	0.571	39.403	39.293	43.807	43.722
Kahramanmaraş	9.589	9.917	4.864	4.791	0.570	0.524	38.167	38.099	44.827	44.740
Diyarbakır-Lice	9.622	9.200	4.873	4.751	0.564	0.549	39.640	39.881	43.428	42.932
Adana-Kozan-2	9.847	9.980	4.990	4.957	0.573	0.541	39.359	39.249	43.317	43.407
Manisa-Salihli	9.529	9.109	4.745	4.613	0.580	0.557	41.236	41.674	43.118	42.233
Manisa-Alaşehir	9.697	10.097	4.728	4.679	0.580	0.571	37.154	37.513	45.082	45.226
Adana-Ceyhan	9.669	10.088	4.926	4.753	0.578	0.563	37.728	38.035	45.211	44.660
Antalya-Kumluca	9.713	10.096	4.839	4.876	0.560	0.541	38.332	38.142	44.541	44.454
Adana-Yumurtalık	9.548	9.964	4.822	4.754	0.531	0.554	38.185	38.165	45.080	44.718
Osmaniye-Kadirli	9.910	10.053	4.889	4.088	0.589	0.571	37.631	37.767	45.063	44.897
Muğla-Fethiye	9.670	10.258	4.976	4.858	0.597	0.562	40.752	41.184	42.129	41.899
Adana-Karataş	9.467	9.699	5.078	5.018	0.551	0.583	40.232	40.623	42.837	42.224
Adana-Sarıçam	9.763	10.010	4.834	4.859	0.601	0.569	39.224	39.086	43.629	43.632
Balıkesir-Ayvalık	9.848	10.189	5.119	4.870	0.590	0.539	38.100	41.348	44.630	43.964
Aydın-Merkez	9.950	10.559	4.806	4.699	0.564	0.535	37.487	37.526	45.254	45.012
Adana- Merkez	9.648	10.021	4.800	4.696	0.567	0.552	37.545	37.348	45.538	45.467

The oil compositions of sesame varieties were compared in five main dominated sesame fatty acid components namely palmitic, stearic, arachidic, oleic and linoleic acid (Table 2). The content of major fatty acids showed significant variation

according to extraction methods (Table 3). Indeed, palmitic and oleic acids were higher in the extracted by cold press. Conversely, stearic, arachidic and linoleic acids were higher in the extracted by soxhlet.

Table 3 Statical analysis of effect of extraction methods on fatty acid composition sesame genotypes

Characters	ANOVA					
		Sum of Squares	df	Mean Square	F	Sig.
Palmitic acid	Between Groups	6.453	24	.269	6.496	.000
	Within Groups	5.174	125	.041		
	Total	11.627	149			
Stearic acid	Between Groups	2.840	24	.118	10.986	.000
	Within Groups	1.347	125	.011		
	Total	4.187	149			
Arachidic acid	Between Groups	.043	24	.002	9.935	.000
	Within Groups	.023	125	.000		
	Total	.066	149			
Oleic acid	Between Groups	172.385	24	7.183	49.570	.000
	Within Groups	18.113	125	.145		
	Total	190.497	149			
Linoleic acid	Between Groups	125.207	24	5.217	97.467	.000
	Within Groups	6.691	125	.054		
	Total	131.898	149			

Among various reported saturated fatty acids, palmitic and stearic acids were the predominant saturated fatty acids of sesame oil with a range of 9.38-10.56 and 4.73-5.12%, respectively (Table 2).

Arachidic acid was a minor constituent of sesame oil with a range of 0.52-0.59%. Oleic and linoleic acids are the major fatty acids of sesame oil (Arslan et al., 2007; Uzun et al., 2008), and they are found to be present in large proportion in the oils of all genotypes. Oleic acid content of sesame oil ranged from 37.15 to 41.67%. While, the highest oleic acid content was determined in the oil of Manisa-Salihli genotype, the lowest content was determined in the oil of genotype Manisa-Alaşehir. Linoleic acid varied between 41.9 to 45.54% (Muğla-Fethiye, Adana-Merkez, respectively). Thus, linoleic acid content of sesame oil was found to be higher than that of oleic acid. The oleic and linoleic acids were the main fatty acids. The high amount of unsaturated fatty acid with a value of 80% of total fatty acids increases the quality of sesame oil (Chung et al., 1995). In present study all the varieties have an amount of oleic and linoleic acid with the value of over 80%. Bozan & Temelli (2002), the conventional extraction method using organic solvents giving a higher extraction yield.

Conclusions

Based on the results of this study, the fatty acid composition of sesame oil varied among Turkish sesame genotypes and there were significant differences observed among the Turkish sesame genotypes for fatty acid composition of oil obtained by two extraction methods.

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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