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Full Length Research Paper

Profiling of major fatty acids in different raw and roasted sesame seeds cultivars

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The aim of this study was to investigate the fatty acids profile of five sesame cultivars including Branching Naz, Darab, Karaj, Dezful and Black sesame and the effect of time and temperature roasting procedure. The seeds oil content varied from 43±0.28 to 47±0.41% with the average content of 44.4±1.87%. Darab and Black sesame cultivar had the highest and lowest oil content respectively. Oleic and linoleic acids were the two-dominant fatty acids in the sesame seed oil about 80 to 85% of the total amount, whereas palmitic and stearic acids were present at 12 to 15%. Moreover, Dazful and Black sesame had the maximum and minimum content of oxidizability value respectively. The results of the present study showed that the fatty acid contents in studied cultivars were steady during different roasting conditions and fatty acid behavior of samples was good fitted with the high temperatures.

Key words: Gas chromatography (GC), fatty acid, roasting procedure, sesame seed, stability.

INTRODUCTION

Sesame (*Sesamum indicum* L.) is known as one of the world's most important oil seed crops and contain 40 to 60% oil (Bedigian, 2004; Dogan and Zeybek., 2009). It belongs to the Tubiflorae order and Pediaceae family (Nayar, 1984). Sesame has long been regarded, in the orient, as a health food, which increases energy and prevents aging (Halvorsen et al., 2002). Plant area and seed production in Iran are about 35,000 to 40,000 ha and 25,000 tons with 729 kg/ha grain yield in average (FAO, 2009).

Sesame oil as high quality amino acids, vitamins, and fatty acids is popular in Iran especially in Fars Province (Biabani and Pakniyat, 2008; Sadeghi et al., 2009). Also roasting is one of the most important sesame seed processing in Iran. Seed roasting before oil extraction gives it a characteristic good flavor and is reported to improve the stability of some oils (Vaidya and Choe, 2011). The remarkable oxidative stability of sesame oil is due to the presence of lignan compounds as well as tocopherols (Choe and Min, 2006). Based on codex standard the considerable fatty acid which presence more than one percent in sesame seeds are oleic, linoleic, palmitic and stearic (CODEX STAN 210-1999).

The calculated oxidizability (cox) value which is based on unsaturated fatty acid percentages present in the oils, is a beneficial element usually taken as an evaluation of the oil's tendency to undergo autoxidation (Fatemi and Hammond, 1980). The main goal of this study was to screen for oil content variability and fatty acid composition among the most popular sesame cultivars in Iran due to few studies focused on minor oils such as sesame. Tree replicates of each sample preparation and analysis were done to evaluate the fatty acid composition and the effect of roasting procedure.

MATERIALS AND METHODS

All solvents were of analytical grade (Merck, Darmstalt, Germany). Double-distilled deionized water was used for the preparation of

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aqueous solutions. Also, the probable fatty acids consist of C12:0, C14:0, C16:0, C16:1, C18:0, C18:1, C18:2 and C18:3 (Sigma, USA) were purchased.

Sesame seeds

Five cultivars of sesame including Branching Naz, Dezful, Darab, Karaj and Black sesame were obtained from Karaj seed and plant improvement institute. The seed cultivars were sealed in a bottle and stored at 4°C until required.

Roasting of seeds

Each sesame seed cultivar, was placed as single layer in Pyrex dishes on the turntable of a convection oven (Memmert, Germany) and was roasted at 180, 200, 220°C, for 10, 15, 20 min separately. The roasted seeds were cooled to ambient temperature before lipid extraction.

Lipid extraction

Two grams of sesame seeds were separately ground, using a stainless-steel grinder and the oil was extracted with soxhlet apparatus for 8 h with n-hexane. The hexane extracts were filtered through lipid-free filter paper and the solvents were removed and flushed with nitrogen. The extracted lipids were weighed to determine the lipid content of the seed and were kept in the dark at 25°C until use.

Saponification

The samples were treated as in the AOAC method number 956.04 (Harwitz, 2000) for preparation of fatty acid solution. A mass of 0.5 g well-mixed sample was transferred to a tube with lip and 5 ml of 50 mg/ml of NaOH in isopropanol was added. The tube was placed 5 cm deep in a boiling water bath for 30 min to saponify the oil and to evaporate the isopropanol. A volume of 0.35 ml of a mixture of concentrated H_2SO_4/distilled H_2O (2:1) was added drop wise to the soap, while the tube was cooled in cold water. Lumps at the bottom of the tube were broken using a glass-stirring rod. A white mixture containing fatty acids clinging to a viscous aqueous K_2SO_4 layer is obtained. Octa decanoic acid ester (3 mg/ml) was used as an internal standard (Internal standards were used to ensure analyses accuracy and to correct for any variation in the GC performance). A volume of 10 ml hexane-butanol (100:1) solution is added to the tube and mixed thoroughly with a glass rod. The organic solution was filtered using a 0.45 µm filter. A volume of 1 µl of the filtrate solution was analyzed by gas chromatography (GC).

GC analyses

GC analyses were performed on model 1000 DPC gas chromatograph (DANI, Milano, Italy) equipped with a split/splitless capillary (1:40) injector and a flame ionization detector. Analytical separation was achieved on an AT-1000 capillary column (25 m × 0.32 mm i.d) with 0.2 µm film thickness (Alltech, Illinois, USA). Nitrogen was used as carrier gas with a constant flow rate of 1 ml/min. The air, hydrogen and auxiliary gas (N_2) pressures for detector were kept 1.1, 0.9 and 0.8 bar, respectively. Temperature setting was as follows: injector, 250°C and detector, 280°C. The oven temperature was held at 180°C for two minute then programmed to 240°C at 22°C/min and held for 25 min at 240°C. The peak areas were used to calculate the fatty acid content (expressed as percentage of total fatty acids).

Each probable fatty acid was injected to identify the fatty acid peaks in chromatograms as a quantitative analysis. A relationship between carbon number and retention time, which can be used to identify fatty acid, was used to recognizing the exact fatty acids. An amount of FA's was achieved from comparing the sample peak areas with the standard peak areas. Since, the internal standard had a known concentration in both sample and standard, it could be used to correct for sample variations.

Calculated oxidizability value (Cox)

The oxidative stability of each cultivars in different roasting programs based on unsaturated fatty acids (USFAs) content was calculated (Fatemi and Hammond, 1980).

$$Cox = [1(18:1\%) + 10.3(18:2\%) + 21.6(18:3\%)]/100.$$

Statistical analysis

All measurements were replicated three times to improve the reliability of the results. Statistical analyses were conducted using statistical program for social sciences (SPSS Corporation, Chicago, IL) version 18 for windows. Significant differences among cultivars were analyzed by using ANOVA- Tukkey post hoc test at level of $p < 0.05$.

RESULTS

Oil content

Environmental condition is a significant effective factor on oil content of cultivars (Gur et al., 1998; Were et al., 2006). The seeds oil content varied from 43±0.28 to 47±0.41% with the average content of 44.4±1.87%. Darab and Black sesame cultivar (cv) had the highest and lowest oil content respectively. Also, Branching Naz, Dezful and Karaj cv. with 44% had the similar oil content (Table 1).

Fatty acid profiles and roasting effect on the sesame fatty acids

The fatty acid composition of seed oils varies widely among different plant species. Unsaturated fatty acids (USFAs) have favorable effect and positive health benefit than saturated fatty acid (SFAs) (Hashempour et al., 2010).

The USFAs contents in the studied cultivars were higher than SFAs and the major fatty acid compositions were oleic (C18:1), linoleic (C18:2), palmitic (C16:0) and stearic (C18:0). Oleic and linoleic acids were the two dominant fatty acids in the sesame seed oil according to 80 - 85% of the total amount, whereas palmitic and stearic acids were present at 12 to 15% (Table 1). In Li et al. (2011) study the sesame fatty acid pattern is also the same.

Lee et al. (1998) used a beneficial ratio of palmitic,

Table 1. Unroasted sesame fatty acids content (%).

Parameter	Oleic acid	Linoeic acid	Palmitic acid	Stearic acid	Oil content
Branching Naz	42.36±0.35	40.61±0.47	10.33±0.39	6.68±0.42	44±0.27
Darab	41.87±0.12	41.49±0.33	8.71±0.28	7.91±0.16	47±0.41
Karaj	44.26±0.51	41.69±0.26	8.99±0.19	5.68±0.19	44±0.36
Dezful	47.98±0.24	35.79±0.11	9.30±0.46	6.90±0.35	47±0.11
Black sesame	39.78±0.17	45.62±0.68	9.65±0.12	4.97±0.51	43±0.28
Codex fatty acid range	35.9-42.3	41.5-47.9	7.9-12.0	4.8-6.1	≥ 45
Fatty acid world collection	32.7-53.9	39.3-59.0	8.3-10.9	3.4-6.0	40.4-59.8

The content of each individual fatty acid ratio is given as a percentage of the corresponding total.

stearic, oleic over linoleic acid as Eigen values to distinguish sesame oil from other edible vegetable oils. The P/L, S/L, and O/L ratios of sesame cultivars in this study were comparable with those reported.

The determined fatty acids and the calculated ratios did not show any changes under roasting conditions and no significant difference was observed (Table 2). In addition, the profitable SFAs to USFAs ratio can be considered as useful index to measure edible oils quality (Lee et al., 1998). The ratio of SFAs to USFAs in analyzed oil samples was found between 0.15 to 0.20, which clearly indicated the high amount of USFAs and can be positively considered from the nutritional point of view. No significant variation was also found in the SFAs to USFAs at different time and temperature, but it seems that a minor difference can be detected in 200°C to 20 min (Table 2). The Cox value of unroasted and roasted cultivars was also determined. Table 3 shows that Dezful and Black sesame cv. had the maximum and minimum Cox values respectively.

DISCUSSION

Oil content and fatty acid profile

In Hiremath et al. (2007) study, oleic and linoleic are the major fatty acids and these fatty acid in studied cultivars were in well agreement with the previous report (Abou-Gharbia et al., 1996). Also in studied cultivars oleic acid was near the maximum of the word collection and higher than the codex ranges (Codex Alimentarius, 2005).

The cultivars cox value approximately increased up to 200°C to 20 min when USFAs are in the most content. The cox value index is calculated based on USFAs percentages, therefore more comprehensive experimental studies about tendency of sesame oil oxidation such as rancidity test or total polar material measurement (TPM) are recommended. Other supportive research showed roasted sesame oil was more stable to oxidation than unroasted sesame oil, the remarkable oxidative stability of sesame oil is relates to the presence of lignan compounds as well as tocopherols (Choe and Min, 2006; Konsoula and Liakopoulou-Kyriakides, 2010; Yoshida et al., 2001).

The cox value results demonstrated that sesame oil is almost stable and it could be used for protection of vegetable oils against oxidative deterioration.

Roasting effect on sesame fatty acids

Briefly, it is essential to note, the whole determined fatty acids were steady during temperature programs and no fatty acid changes are substantially observed, although further investigation about stability indicating test are also recommended.

The results from previous studies (Jannat et al., 2010; Hajimahmoodi et al., 2008) provide useful background information which showed almost the same stable trend in antioxidant and total phenolic content. In Vaidya research, the absolute amounts of sesame fatty acid were slightly decreased, but seeds roasting did not affect the fatty acid composition of the seed oil (Vaidya and Choe, 2011). There is limited number of scientific researches about the sesame oil usage and explore the economics and market potential for pressing sesame in Iran on an industrial scale.

Yoshida and Takagi (1997) introduced the optimum roasting condition for sesame as 25 min at 160 or 180°C, 15 min at 200°C and 5 min at 220°C.

In the present study, the roasting temperature was not over 220°C because in Iran, generally applied temperatures for sesame roasting are below 200°C.

A traditional food in Iran is “Halwa-Ardeh” which is produced by blending the roasted sesame paste at about 200°C (Ardeh) with a proper sweetener such as date syrup. The results of the present study showed that the fatty acid content in “Halwa-Ardeh” was good fitted with the high temperatures.

The temperature does not cause a major problem for the sesame industry and hereafter local industry experts of sesame which are taken under high temperatures should be conducted easily. This achievement is valuable for various uses such as meal, paste, confections, and bakery products. However, it will be necessary to find

Table 2. Palmitic, stearic, oleic to linoleic acid ratios and also saturated to unsaturated fatty acid of roasted sesame seeds in different times and temperatures.

Different conditions	Fatty acids ratio	Branching Naz	Darab	Karaj	Dezful	Black sesame
Unroasted	P/L	0.25	0.21	0.21	0.26	0.21
	S/L	0.16	0.16	0.13	0.19	0.10
	O/L	1.04	1.00	1.04	1.34	0.87
	SFA/USF	0.20	0.20	0.17	0.19	0.17
180°C-10 min	P/L	0.26	0.21	0.20	0.23	0.17
	S/L	0.15	0.17	0.14	0.17	0.11
	O/L	1.08	0.97	1.00	1.27	0.89
	SFA/USF	0.20	0.19	0.17	0.18	0.17
180°C-15 min	P/L	0.24	0.20	0.21	0.23	0.17
	S/L	0.15	0.17	0.14	0.18	0.11
	O/L	1.07	0.97	1.03	1.28	0.85
	SFA/USF	0.19	0.19	0.17	0.18	0.17
180°C-20 min	P/L	0.23	0.20	0.21	0.22	0.16
	S/L	0.15	0.17	0.14	0.17	0.10
	O/L	1.02	0.89	1.05	1.19	0.84
	SFA/USF	0.19	0.19	0.17	0.18	0.16
200°C-10 min	P/L	0.23	0.20	0.21	0.22	0.16
	S/L	0.16	0.15	0.13	0.17	0.10
	O/L	1.02	0.97	1.04	1.26	0.84
	SFA/USF	0.19	0.18	0.17	0.17	0.16
200°C-15 min	P/L	0.23	0.21	0.21	0.23	0.16
	S/L	0.16	0.15	0.13	0.17	0.09
	O/L	1.07	1.00	1.04	1.27	0.84
	SFA/USF	0.19	0.18	0.16	0.18	0.16
200°C-20 min	P/L	0.22	0.19	0.19	0.21	0.15
	S/L	0.15	0.14	0.12	0.15	0.09
	O/L	1.05	1.03	1.05	1.22	0.88
	SFA/USF	0.18	0.16	0.15	0.16	0.15
220°C-10 min	P/L	0.22	0.19	0.20	0.21	0.16
	S/L	0.15	0.17	0.13	0.16	0.10
	O/L	1.03	0.99	1.01	1.25	0.85
	SFA/USF	0.18	0.18	0.16	0.17	0.16
220°C-15 min	P/L	0.23	0.20	0.19	0.23	0.16
	S/L	0.16	0.16	0.13	0.17	0.10
	O/L	1.05	1.01	1.02	1.29	0.80
	SFA/USF	0.19	0.18	0.16	0.17	0.16
220°C-20 min	P/L	0.23	0.20	0.22	0.22	0.16
	S/L	0.16	0.17	0.15	0.17	0.10
	O/L	1.09	0.99	1.12	1.27	0.86
	SFA/USF	0.18	0.18	0.17	0.17	0.16

Table 3. The Cox value of roasted sesame seeds in different times and temperatures.

Cox value	Branching Naz	Darab	Karaj	Dezful	Black sesame
Unroasted	46.54±0.34	46.14±0.17	47.91±0.76	51.67±0.98	44.44±0.93
180°C-10 min	47.19±0.51	45.72±0.26	47.51±0.49	51.28±0.78	44.74±0.37
180°C-15 min	47.56±0.45	45.78±0.93	47.59±0.11	51.35±0.76	43.88±0.15
180°C-20 min	46.73±0.12	45.9±0.72	48.05±0.27	50.15±0.45	43.99±0.82
200°C-10 min	46.47±0.70	46.25±0.55	47.98±0.46	51.29±0.24	43.94±0.61
200°C-15 min	47.49±0.19	46.53±0.34	47.99±0.18	51.17±0.07	44.03±0.59
200°C-20 min	47.35±0.32	47.87±0.14	48.59±0.80	51.07±0.85	45.57±0.94
220°C-10 min	47.07±0.57	46.45±0.09	47.51±0.67	51.43±0.18	44.35±0.15
220°C-15 min	47.19±0.82	46.8±0.56	47.87±0.31	51.75±0.29	44.65±0.37
220°C-20 min	48.16±0.73	46.35±0.82	49.08±0.17	51.46±0.76	44.42±0.22

other impressive factors indicating fatty acid stability during roasting to confirm results from this study.

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