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Influence of Roasting Treatments on Oil Quality Properties of Two Sesame Seed Varieties

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Abstract

The objective of this study was to evaluate the effect of roasting at 160°C for 5, 10 and 15 minutes on physicochemical properties, lipid oxidation, fatty acids profile, rancimat value, conjugated dienes and conjugated triene content of Giza 32 and Shandaweel 3 sesame seeds varieties. Results showed that all studied samples contained moisture (3.60 - 5.98%), crude protein (22.92 - 24.31%), oil (51.68 - 55.26%), fiber (7.12 - 8.14%), ash (3.92 - 4.73%), and carbohydrates (9.63 - 12.01%); in raw and roasted sesame seed varieties (RSS). Data revealed that acid value, peroxide value, TBA, conjugated diene and conjugated triene, increased gradually by roasting treatments of seeds, while the iodine value was slightly decreased by roasting. A little changes in the saturated and unsaturated fatty acids were found during roasting. Palmitic acid was the predominant saturated fatty acids followed by stearic acid, while oleic and linoleic acids recorded the highest levels among unsaturated fatty acids in both sesame oils. Data also revealed that the thermal stability (Rancimat value) of sesame oils was enhancement by roasting treatments.

Keywords: *Sesame seeds, roasting process, physicochemical properties, fatty acids, Rancimat value.*

Introduction

Sesame (*Sesamum indicum*) is a member of the Pedaliaceae plant family. The sesame is one of the world most important and oldest known oil seed crops. It took the 9th position among the top 13 oil seed crops which make up 90% of the world production of edible oil (Adeola *et al*., 2010). World production of sesame seeds was about 5.531.948 Million tons (MT) in 2017. Egypt produced about 44.000 MT (FAO STAT Database, 2017). It is an economically important oil seed crop which is widely cultivated in many parts of the world, primarily in tropical and has recently been adapted to semi-arid regions (Elleuch *et al.,* 2007).

Sesame seed is rich in oil, protein, carbohydrates, fiber and some minerals. Sesame seeds are an important source of oil (44–58%), crude protein (18–25%), carbohydrate (13.5%) and ash (5%). Physicochemical properties of the oil showed specific gravity, 0.91; refractive index, 1.471; acid value, 4.488 mgKOH/g; iodine value, 112.21 g/100g; peroxide value, 6.0 meq O_2/kg oil; saponification value, 192.24 mgKOH/g oil and free fatty acids, 2.24% oleic acid (Olasunkanmi *et al.,* 2017). Sesame seed contains approximately 35% monounsaturated fatty acids and 44% polyunsaturated fatty acids and its meal (about 45%) contains 20% protein (Hansen, 2011).

The major saturated fatty acids in sesame seed oils were palmitic (6.06-9.03%) and stearic (5.29-6.42%) with small arachidic (0.19-0.71%) acids. The main unsaturated fatty acids of sesame oil were linoleic (38.11-47.11%) and oleic (36.83-44.49%) of total lipids (Matthäus and Özcan, 2018). The oil seed is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air (Global AgriSystems, 2010). The high stability of sesame oil towards oxidation could be attributed to its high natural antioxidants; lignans (sesamol, sesamolin and sesamin) together with tocopherols (Ali *et al*., 2007)

Oil from roasted sesame seeds has characteristic odour and taste and possesses higher oxidative stability than other vegetable oils although their high concentration of unsaturated fatty acids. The exceptionally high oxidative stability in sesame oil has been reported to relate closely with the presence of lignans such as sesamolin, sesamin, sesamol, tocopherols, and Maillard reaction products (Shahidi & Naczk., 2004 and Lee *et al.,* 2007). The roasting process introduces chemical composition changes in the sesame seeds and oil. It is reported that the oxidative stability of sesame oil depends on the roasting temperature. At higher roasting temperatures a strong flavor is obtained, but the quality of the oil may be reduced (Bozkurt, 2007 and Lee *et al*., 2012). There for this study aims to clarify the roasting time required to prepare the sesame seeds oil with a good quality and highest oxidative thermal stability of two Egyptians sesame seeds varieties.

Materials and Methods

Sesame seeds samples:

Seeds of two Egyptians sesame varieties used in this study; Giza 32 (G32) was obtained from the Crops Department farm, Faculty of Agriculture, Assiut University, and Shandaweel 3 (Sh3) which obtained from Oil Crops Department, Field Crops Research Institute, Shandaweel Research Station, Agricultural Research Center, Egypt. All sesame seed samples were collected during 2018 season. Sesame seeds were manually cleaned to remove the foreign matters over lapping with seeds and divided into two groups. The first amount stay as a raw sesame seeds (as a control), while the second sesame seeds amount was roasted at 160ºC for 5, 10 and 15 min using an electrical drying oven, (Model D-63450, Hanau, Germany). Samples of untreated and treated sesame seeds were immediately evaluated for their physicochemical properties. The reminder seeds were kept for further uses.

Oil sesame seeds extraction:

Sesame oil was extracted from all samples by pressing method using a local traditional mill and filtrated with filter paper. The obtained oil dried on anhydrous sodium sulphate, some of them were immediately analyzed and the rest of oil kept for further analysis.

Analytical methods:

Chemical composition of sesame seeds:

Moisture, crude protein, crude oil, crude fiber and ash contents of raw and roasted sesame seed samples were determined according to AOAC (2005). Total carbohydrates were calculated by difference.

Physicochemical properties of sesame oil:

Specific gravity, peroxide values (PV), acid value (AV), iodine value, saponification value were estimated according to AOCS (1998).

TBA value (Thioparbituric acid) was estimated spectrophotometry at 532 nm according to Guzman-Chozas *et al*. (1997). Refractive index (RI) was determined by an Abbe 60 refractometer at 25°C (AOAC, 2005).

Calculated oxidizability value:

The oxidative stability of the extracted oils based on unsaturated fatty acids (USFAs) content was calculated according to Fatemi and Hammond (1980) as follows**:**

Oxidizability = [1(oleic %) + 10.3(linoleic %) + 21.6(Linolenic %)]/100.

Oxidative stability by Rancimat method:

Three grams of oil was accurately weighed into each of the six reaction vessels, and carried out according to the method described by Hasenhuettl and Wan (1992). The Metrohm Rancimat 679 (Metrohm Ltd., Herisau, Switzerland) was switched on until the temperature of the oil batch reached 120°C.

Fatty acids composition:

Fatty acid methyl esters were prepared from total lipids by using rapid method according to ISO 12966-2 (2011). Fatty acid methyl esters were injected into (HPLC 6890 series GC) apparatus provided with a DB-23 column (60m × 0.32mm × 25 µm). Carrier gas was N2 with flow rate 2.2 ml/min, splitting ratio of 1:50. The injector temperature was 250 °C and that of Flame Ionization Detector (FID) was 300°C. The temperature setting was as follows: 150°C to 210°C at 5°C/min, and then held at 210°C for 25 min. Peaks were identified by comparing the retention times obtained with stander methyl esters.

Conjugated dienes and triene:

A Shimadzu UV-1601 PC, UV-Visible spectrophotometer, with the UVPC Personal spectroscopy software version 3.91, was used to determine absorptivity at the UV spectrum. The ultraviolet absorbance at 232-234 nm for conjugated dienes formation and at 268-270 nm for conjugated triene formation as mentioned by (Gray, 1978; Chiou, 1992; Vieira and Regitano-Darce, 1999), were measured on a spectrophotometer. About 0.1 g of the oil was accurately weighed, dissolved in hexane and transferred quantitatively to a 50 ml glass-stoppered volumetric flask. The absorbance was corrected calculate to $E^{1\%}_{1cm}$ at all wave lengths using the following formula:

$$E^{1\%}_{1cm} = A/C \times D$$

Where; **A**: the absorbance of the solution at the specified wavelength, **C**: the concentration of the oil in g/100 ml of the solution, and **D**: the length of the cell in cm.

Resuls and Dissection

Chemical composition of raw and roasted sesame seeds

The gross chemical composition of raw and roasted sesame seed samples (RSS) are presented in Table 1. Data revealed that moisture content 3.60 – 5.98%. while crude protein, crude oil, crude fiber, ash and carbohydrates contains were 23.46 - 24.58 %, 51.68 – 55.26 %, 7.12 - 8.14 %, 3.92 to 4.73% and 8.93 - 12.01%; respectively of raw and roasted sesame seeds. From the obtained results it was clear that sesame seeds contained a high level of oil and protein, and it has an important nutritional value. The roasted sesame seeds at 160□ C for 15 min had the highest oil content compared unroasted samples. Variation in oil during treatments may be linked to the processing method applied. In fact, during roasting the concentration of organic matter like oil increases in the seeds due the moisture loss (Beshara, 2006).

The variations in the chemical composition between two studied sesame seeds varieties might be due to differences between varieties and cultivation conditions and roasting. In general, it could be concluded that Shandaweel 3 and Giza 32 roasted sesame seeds were better for the oil industry than the unroasted sesame seeds. Such results are in agreement with those previously reported by Ghandi (2009), Akinoso *et al.* (2010), Hassan (2012), Asghar & Majeed (2013) and Hama (2016).

Table 1. Gross chemical composition* of raw and roasted sesame seeds varieties (% on dry weight basis except moisture on wet weight)

Sesame seed Samples	Moisture	Crude protein	Crude oil	Crude Fiber	Ash	Carbohydrates[a]
Giza 32 (Raw)	5.16	23.46	52.72	8.14	3.92	11.76
Giza 32 (RSS)[b]	3.60	23.62	55.26	8.02	3.97	9.13
Shandaweel 3 (Raw)	5.98	24.21	51.68	7.39	4.61	12.01
Shandaweel 3 (RSS)[b]	3.97	24.58	54.64	7.12	4.73	8.93

* Mean of triplicate, % on dry weight basis.
a: Calculated by differences.
b: Roasted sesame seeds at 160°C for 15 min.

Effect of roasting on some properties of sesame seeds oil

The characteristics and quality of sesame seed oils roasted at 160°C for 5, 10 and 15 min, are shown in Table 2. From these results, it could be noticed that the acid value of the studied sesame oil showed a little increase with roasting time increase. The increasing in acid value could be interpreted in terms of hydrolysis of lipids. Abou-Ghariba *et al.* (2000) found that the free fatty acids (FFA) were increased in sesame seed oil with roasting process. These results are in agreement with those reported by Hassan (2012) and Tenyang *et al.* (2017). The increase in FFA of the oil might be attributed to thermal decomposition of triacylglycerol.

Data in Table 2 revealed that during heat treatment, a few change in unsaturation was observed in all studied oils by measurement of iodine value. The iodine value gradually decrease from 105.38 to 105.14 and from 103.11 to 102.96 for raw and roasted (160°C/15 min) of Giza 32 and Shandaweel 3 oils; respectively. These results are in good agreement with those reported by Tenyang *et al.* (2017).

Data also showed that the peroxide and TBA values were increased in roasted sesame seed oils. It was observed that the peroxide value (PV) was also increased by roasting time progress which might be due to the lipid oxidation occurred throughout roasting process. The increase in peroxide value might be due to the acceleration of dry heat in the presence of air, breakdown and decomposition of fatty acids to form peroxide compounds. Whereas, the increasing of TBA value might be due to formation of several products during roasting such as carbonyl compounds, malonaldehyde, formaldehyde and hdyroperoxides. These results are in the line with those reported by Beshara (2006), Abo khashaba *et al.* (2014), Borojeni *et al.* (2016) and Tenyang *et al.* (2017).

Table 2. Effect of roasting process on characteristics of sesame seed oil

Sesame oil characteristics	Roasting time at 160°C							
	Giza 32 oil				Shandaweel 3 oil			
	Raw 0 min	5 min	10 min	15 min	Raw 0 min	5 min	10 min	15 min
Acid value	0.97	1.09	1.18	1.23	0.86	0.92	1.11	1.19
Saponification number	195.37	194.92	196.11	195.88	193.15	193.14	194.22	194.55
Iodine value	105.38	105.33	105.22	105.14	103.11	103.08	103.04	102.96
Peroxide value	1.58	1.62	1.83	2.08	1.41	1.44	1.62	1.81
TBA	0.562	0.570	0.592	0.620	0.524	0.530	0.552	0.598

Shahidi and Naczk (2004) reported that sesame seed contains two lignans compounds; sesamin and sesamolin. After roasting process using high temperature of sesame seeds, sesamolin converted to sesamol or sesamol dimmers which have higher anti-oxidative effects. While chemical refining and bleaching process converts sesamolin into sesaminol and sesamol. Increase of sesamol formation in sesame oil as sesame seeds received high thermal energy from roasting process has been reported. Sesamin and sesamolin are reported not to possess high free radical scavenging activity compared to sesamol (Suja *et al.,* 2004).

Data in Table 3 showed that, Rancimat value (hours) at 120°C gradually increased with roasting time increasing at the same temperature (160°C±5). It was increased from 1.87 and 0.68 for raw sesame seeds to 8.28 and 6.62 hours as a result of roasting process after 15 min for Giza 32 and Shandaweel 3 sesame seeds; respectively. These results revealed that the antioxidant activity of the extracted oil increased as the roasting process of sesame seeds increased. Such results are in the same line with those reported by Abou-Gharbia *et al.* (2000), Shahidi & Naczk (2004), Lee *et al.* (2007), Lee *et al.* (2010), Akinoso *et al.*(2010) and Abo khashaba *et al.* (2014).

Table 3. Effect of roasting on Rancimat value (hours)

Sesame seeds treatment		Rancimat value (hours) at 120°C of oil	
		Giza 32	Shandaweel 3
Raw		1.87	0.68
Roasting at 160°C±5 for:	5 min	3.68	1.48
	10 min	5.10	4.53
	15 min	8.28	6.62

Effect of roasting on fatty acids of sesame seeds

Fatty acid contents of sesame seeds oil samples are shown in Table 4. The predominant fatty acids in all studied samples were oleic (C18:1), linoleic (C18:2) and palmitic (C16:0) in the studied sesame oils. The total unsaturated fatty acids slightly decreased from 85.80 and 84.7% of raw samples to 85.50 and 84.45% of total fatty acids after roasting process at 160°C for 15 min for Giza 32 and Shandaweel 3 sesame seed oils; respectively. However, data revealed that the saturated fatty acids were slightly increased from 14.17 and 15.29% to 14.50 and 15.55% of total fatty acids in the same samples; respectively at the same roasting process. These results are in accordance with those reported by Abo khashaba *et al.* (2014) and Ji *et al.* (2019).

Table 4. Effect of roasting on fatty acids composition of sesame seeds oil (% of total fatty acids)

Fatty acids	Carbon chain	Roasting time at 160° C							
		Giza 32 oil				Shandaweel 3 oil			
		Raw 0 min	5 min	10 min	15 min	Raw 0 min	5 min	10 min	15 min
Myristic	$C_{14:0}$	0.02	0.02	0.03	0.02	0.02	0.02	0.03	0.02
Palmitic	$C_{16:0}$	8.55	8.63	8.72	8.75	8.88	8.94	9.07	9.10
Palmitoleic	$C_{16:1}$	0.11	0.11	0.11	0.11	0.11	0.11	0.16	0.12
Stearic	$C_{18:0}$	4.87	4.88	4.90	4.93	5.62	5.62	5.55	5.67
Oleic	$C_{18:1}$	42.69	42.73	42.68	42.67	42.59	42.59	42.49	42.68
Linoleic	$C_{18:2}$	42.25	42.21	42.14	41.94	41.35	41.29	41.33	41.08
Linolenic	$C_{18:3}$	0.51	0.46	0.45	0.49	0.42	0.42	0.40	0.35
Arachidic	$C_{20:0}$	0.58	0.59	0.59	0.65	0.64	0.64	0.62	0.63
Gadoleic	$C_{20:1}$	0.24	0.23	0.24	0.29	0.23	0.23	0.22	0.22
Behenic	$C_{22:0}$	0.15	0.14	0.14	0.15	0.13	0.14	0.13	0.13
Total saturated		14.17	14.26	14.38	14.50	15.29	15.36	15.40	15.55
Total unsaturated		85.80	85.74	85.62	85.50	84.70	84.64	84.60	84.45

Oxidative stability of sesame seed oils:

Oils containing linoleate or more highly unsaturated fatty acids are oxidized to conjugated diene systems (Gray, 1978). Conjugated dienes exhibited an intense absorption at 232-234 nm; while, conjugated trienes absorb at 268-270 nm; was a good index for measuring of oxidation.

Data in Table 5 revealed that conjugated diene and trienes value increased with roasting time progress, whereas, conjugated diene increased from 1.86 and 1.81 of untreated seeds to 1.99 and 1.97 of roasted seeds (15 min) of Giza 32 and Shandaweel 3; respectively. However, conjugated triene increased from 0.72 and 0.67 to 0.86 and 0.83 for the same samples; respectively. Such findings are in good agreement with that reported by Beshara (2006).

Table 5. Conjugated diene and triene values, and oxidative stability of sesame seeds oil

Characteristics	Roasting time at 160° C							
	Giza 32 oil				Shandaweel 3 oil			
	Raw 0 min	5 min	10 min	15 min	Raw 0 min	5 min	10 min	15 min
Conjugated diene	1.86	1.89	1.92	1.99	1.81	1.85	1.91	1.97
Conjugated triene	0.72	0.78	0.79	0.86	0.67	0.71	0.77	0.83
Calculated oxidizability	4.889	4.902	4.684	4.849	4.776	4.769	4.768	4.734
Linoleic/oleic ratio	98.969	98.783	98.735	98.985	97.089	96.948	97.27	96.251
Linolenic/oleic ratio	1.195	1.077	1.054	1.156	0.986	0.986	0.941	0.820

It could be noticed that the conjugated triene values were lower than that of conjugated dienes. Such difference might be due to conjugated triene formed only on fatty acids containing three or more double bonds, and as mentioned previously (Table 4). The percentage of such fatty acids was not more than 0.51% in all studied samples. Such findings are in good accord with Beshara (2006).

Tabulated date also revealed that calculated oxidizability of oils was changed by roasting time. These results might be due to change values of linoleic/oleic and linolenic/oleic ratio.

Conclusion

Sesame seeds are rich in oil and protein content. Palmitic, stearic, oleic and linoleic acids were quantitatively the most important fatty acids in the studied sesame oils. The physio-chemical properties of sesame seeds and its oil were affected during roasting process. The roasting process at 160° C for 15 min recorded the highest oil oxidative stability compared with the untreated and other roasted sesame seeds samples.

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تأثير معاملات التحميص علي خصائص جودة الزيت لصنفين من بذور السمسم

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قسم علوم وتكنولوجيا الأغذية – كليه الزراعة – جامعة أسيوط

الملخص

تهدف هذه الدراسه الي تقييم تأثير التحميص عند ١٦٠ْم لمدة ٥ ، ١٠ و ١٥ دقيقة علي الخواص الفيزيائية والكيميائية وأكسدة الدهون وتركيب الأحماض الدهنية وقيمة الرانسيمات وقيمه الدايين والترايين لصنفين من بذور السمسم هما جيزه ٣٢ وشندويل ٣ . أظهرت النتائج المتحصل عليها أن البذور تحتوي علي رطوبة (٣,٦٠ - ٥,٩٨%). وكانت نسبة البروتين (٢٢,٩٢ - ٢٤,٣١%)، الزيت (٥١,٦٨ - ٥٥,٢٦%)، الألياف (٧,١٢ - ٨,١٤%)، الرماد (٣,٩٢ - ٤,٧٣%) والكربوهيدرات (٩,٦٣ - ١٢,٠١%) وذلك علي أساس الوزن الجاف في عينات بذور السمسم الخام والمحمصه. وأيضا تبين من النتائج أن عملية التحميص أدت الي زيادة طفيفة وتدريجيه في قيمة الحموضة والبيروكسيد وقيمة الدايين والترايين بزيادة وقت التحميص، بينما لوحظ انخفاض تدريجي طفيف في قيمة الرقم اليودي. كما لوحظ تغير بسيط في كمية الأحماض الدهنية المشبعة وغير المشبعة أثناء التحميص، وكانت الأحماض الدهنية المشبعة السائدة هي البالمتيك والأستياريك، بينما كانت نسبة كلاً من حمض الأوليك واللينوليك هي الأعلي بين الأحماض غير المشبعة في الزيت. كما لوحظ من نتائج الرانسمات زيادة الثبات الحراري للزيت الناتج من بذور السمسم بعد التحميص خاصةً بعد ١٥ دقيقة علي درجة الحرارة المستخدمة.