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Effect of some heat treatments on chemical composition and oil characteristics of sesame seeds (*sesamum indicum* l.)

Abo khashaba. A. M.[1]; Omayma E.Shaltout[2];Entisar.A.El-Difrawy[2]; A. M. Abou El-yazeed[2] and M. E. I. El- Sorady.[1]

[1]Oil and Fat Department, Food Technology Research Institute, Agricultural Research Center, Giza, Egypt.

[2]Food Science Department, Faculty of Agriculture Saba Basha, Alex. University, Alexandria, Egypt.

ABSTRACT

Proximate chemical compositions of black and white sesame seeds (*Sesamum indicum* L.) were determined. The chemical properties after heat treatment of white seeds at 60 & 80ºC for (10 & 15 min) as compared to their raw counterparts were determined. Bioactive components of sesame oils, namely, lignans, tocopherols and total phenols were determined in raw black and white seeds then determined in white seeds after heating. Results indicated that the black and white sesame seeds contained high proportions of oil (52.82 and 56.24 %) and protein (20.14 and 20.91%), respectively. Sesame seeds were found to be good sources of minerals, where calcium exhibited the highest value among the other determined minerals in black seeds (0.97%) and (1.08%) in white seeds. Both Iron and Zinc were present in almost equal amounts in both seeds (372 & 230.6 mg/ kg) in white seeds and (340 & 289.4 mg/ kg) in black seeds, respectively. Palmitic and linoleic acids were the predominate fatty acids in sesame oil as measured by GC. After heating, the saturated fatty acids were increased while the unsaturated fatty acids were decreased. Lecithin and carob seeds powder were added to white tehina at different levels to delay the separation process of oil that might take place in tehina paste. Results showed that by adding carob seeds powder at (15 & 20%) significantly delayed separation time up to 45 & 60 days, respectively.

Keywords: Sesame seeds, proximate composition, chemical properties, fatty acids, minerals, lignans and total phenols.

INTRODUCTION

Sesame (*Sesamum indicum* L.) belongs to family *Pedaliaceae,* and is one of the most ancient crops and oilseeds known and used by mankind. It is also known as beniseed, gingelly, ajonjoli, sesamo and till. It was a major oilseed crop in the ancient world due to its easiness of extraction, great stability, and resistance to drought. The major world producers include India, Sudan, China and Burma (who contribute about 60% of the total world production) (El Khier *et al*, 2008). As for Tunisia, 80% of the needed sesame seed is imported from Sudan and 20% from Egypt (Borchani *et al*., 2010). The largest producer of the crop in 2007 was India, China, Myanmar, Sudan, Ethiopia, Uganda and Nigeria. In Egypt, the major part of the imported sesame is essentially transformed to Halaweh. This food product is obtained after mixing the white tehini (white sesame seed dehulled, roasted and grinded), saponin (*Saponaria officinalis*) and Nougat (heat-treated sucrose)

(Abu- Jdayil *et al*., 2002). India used sesame oil in culinary purposes and as a traditional medicine (Reshma *et al*., 2010). However, it has long been regarded as a health unique food.

Sesame seed is rich in fat, protein, carbohydrates, fiber and some minerals. The oil seed is renowned for its stability because it strongly resists oxidative rancidity even after long exposure to air (Global AgriSystems, 2010). The chemical composition of sesame
shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (~13.5%) and ash (~5%) (Borchani *et al*., 2010). Sesame seed is approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein) (Ghandi,2009; Hansen, 2011). The oil also contains oleic (35.9-47%), linoleic (35.6-47.6), palmitic (8.7-13.8%), stearic (2.1-6.4%), as well as arachidic acids (0.1-0.7%) (Elleuch *et al*., 2007; Borchani *et al*., 2010).

Sesame seed contains two lignans, sesamin and sesamolin. After roasting sesame seeds, sesamolin is converted to sesamol. Sesamol has been found to have anti- oxidative effects and to induce growth arrest and apoptosis in cancer cells. In recent times, the anti-photo-oxidant activity of sesamol for oil has been reported to be due to the scavenging of single singlet oxygen. Sesamol has a phenolic and a benzodioxide group in its molecular structure. The phenolic groups of molecules are generally responsible for the anti-oxidant activity of many natural products.

Various interesting physiological activities of sesame lignans in animal and human tests such as hypocholesterolemic activity, suppressive activity of chemically induced cancer and enhancing effect of liver activities involving detoxification of carbon tetrachloride and ethanol were observed. Several epidemiological and clinical studies have indicated a strong positive association of intake of dietary and non-dietary phytochemical and health (Reshma *et al*., 2010). It has been also, suggested that sesame seeds and oil could have a positive effect on cholesterol levels because of their remarkable antioxidant function. Also, sesame seeds and oil have a very high level of unsaturated fatty acids, which is assumed to have reducing effect on plasma cholesterol, as well as on coronary heart disease.

Sesame oil is known to be significantly resistant to oxidative rancidity although it contains nearly 85% unsaturated fatty acids (Yen and Shyu, 1989; Abou-Gharbia *et al.*, 2000). Natural antioxidants such as phenolics and lignans are found in various plant products (such as fruits, leaves, seeds, and oils) (Jeong *et al*., 2004) and they are known to protect easily-oxidizable constituents of food from oxidation. Research has mainly been focused on sesame lignans, which are present in small amounts in sesame oil, and particularly on their efficacy in inhibiting lipid oxidation (Mohamed and Awatif, 1998) as well as on their possible synergistic action with tocopherols (Fukuda *et al*., 1986; Shahidi *et al*., 1997).

Increasing the production of sesame seeds as a vegetable oil crops in Egypt is recommended to overcome the great shortage (90%) of the edible oil production. Egypt is known to have high sesame seeds yield production per area in the world. The oil shows high quality, resistance to oxidation and

high bioactive lignans. The oil reported to have unique functional, physiological, bioactive and nutritional properties and also is suitable for use as salad and frying oils. Sesame seeds are not only a good source of edible oil, but are also widely used in baked goods and confectionery products (Awatif *et al.,* 2013).

Roasting is a key unit operation that influences color, composition, and quality as well as oxidative stability of sesame oil (Yen and Shyu 1989). On the other hand, the phenolic compounds of sesame oil need to receive much attention in relevance to stability of sesame oil. Therefore, the present work aims to study the effect of heating at different temperatures (60ºC and 80ºC) for different times (10 and 15 min) on the natural antioxidants, the stability and the fatty acid composition of sesame oil, also to investigate the effect of adding carob seeds powder and lecithin to tahini.

MATERIALS AND METHODS

Materials:

Sesame seeds: White and Black sesame seeds were purchased from a local market in Kafrelsheikh, Egypt.

Chemicals:

All chemicals used (analytical grades) were purchased from El-Gomhouria Pharmaceutical Company and El-Nasr Pharmaceutical Chemicals Company, Alexandria, Egypt.

Reagents and Standards:

Folin- Ciocateu reagent was obtained from Gerbsaure Chemical Co. Ltd. Germany, caffeic acid and tocopherol standards were purchased from Sigma Chemical Co. (St. Louis, Mo).

Methods:

Proximate chemical analysis of sesame seeds:

Moisture content of sesame seeds was determined according to AOAC (2007).The crude fat was determined by soxhlet with hexane (60 - 80°C) for 8 h. The crude protein was estimated using microkjeldahl procedure using the general factor (6.25). The ash content was determined by combustion of the sample in a muffle furnace at 550°C for 12 h (AOAC. 2007). The crude fiber content was determined as described by the AOAC. (2007). Nitrogen free extract (N. F. E.) was calculated by difference. All determinations were done in triplicates.

Minerals analysis:

The mineral constituents (Ca, K, Mg, Na, Fe and Zn) were analyzed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Tokyo, Japan). Phosphorus content (P) was determined spectrophotometry by the phosphomolybdate method (AOAC, 1990).

Chemical analysis of sesame seeds oils:

Sesame seeds oil extraction:

The oil from crushed seeds was extracted by shaking with petroleum ether for 72 hours at room temperature. This process was repeated three times using fresh solvent each time in order to extract most of the oil from sesame seeds. The miscella was filtered and then evaporated under vacuum

at 50^{o}C. The oil obtained was dried on anhydrous sodium sulphate and kept for further analysis. (El khier, *et al*., 2008).

Chemical properties of oils:

Acid value, saponification value, peroxide value and iodine value were determined according to AOAC (2007).

Fatty acid composition:

Fatty acid methyl ester preparation:

Fatty acid methyl ester was prepared according to Radwan, S.S., (1978), and then the fatty acid methyl ester was separated by a GC device Model: HP (Hewlett Packard) 6890 series GC apparatus. Detector was FID (Flame Ionization Detector). Detector temperature was 250^{o}c. Injector temperature was 220^{o}c, injection volume 2 µl, splitless mode. Column used HP-5 (5% diphenyl, 95% dimethyl polysiloxane), 30 m, 0.32 mm ID, 0.25µm film thicknes. The carrier gas used nitrogen, gas flow speed was 1 m/min.
Oven Program was as follows: Initial temp. 150^{o}c for 2 min.

Ramps	Rate ^{o}C / min	Final temp.	Hold time
1	10	200	-
2	5	250	9 min

Determination of total phenolics content:

Total phenolics content of sesame methanol extract was determined with the Folin- Ciocalteu (FC) reagent as previously described by (Velioglu, *et al*., 1998). The extract (100 µl) dissolved in methanol were mixed with 750 µl of FC reagent (previously diluted 10- fold with distilled water) and allowed to stand at 22°C for 5 min; 750 µl of Na_2CO_3 (60 g/l) solution was added to the mixture. After 90 min, the absorbance was measured at 725 nm using the colorimetric method. Results were expressed as Gallic acid equivalents (mg of Gallic acid/ kg dry weight extract).

Determination of Lignans:

Lignans extraction:

Preparation of defatted sesame seeds powder:

Sesame seeds were ground in a coffee grinder to obtain a fine powder. The samples were defatted by blending the ground materials with hexane (1:6 w/v, 16hr) at room temperature. The defatted powder was air dried for 18 hr and stored at -20 ^{o}C for the later use.

Lignans extraction:

Lignans were extracted using the method described by Zhang *et al*., (2007). 200gm of defatted powder was blended with 1.2 L complex solvent of ethanol and water (50-100% v/v) at room temperature for 24 h. The extract was filtered using a sand core funnel, and then it was concentrated at 40 ^{o}C with a rotary evaporated at 90 rpm. Light yellow syrup was obtained. The syrup was hydrolyzed with 1M from NaOH at room temperature for 16 h. The hydrolyzed syrup was acidified with 1M HCL to pH 6, which was measured using pH meter (Autech, 1500) The solution was cooled down to 15 ^{o}C, and then it was centrifuged with a high-speed centrifuge (Hettich, model Rota fix 32) at 2000 rpm for 10 min to precipitate and remove water-soluble polysaccharides and proteins after filtering the salt with a sand core funnel (Prasad, 2004). After freeze-drying process, the weight of lignans was

determined and the acquired ratio of lignans was calculated using the following equation:

$$\text{Acquired ratio of lignans (\%)} = \frac{\text{Weight of freeze-dried lignans}}{\text{Weight of defatted sesame powder}} \times 100$$

Determination of Tocopherols:

Tocopherols were extracted using the method described by Gliszczyńska-Świgło & Sikorska (2004) which involved weighing 1 g of sample and transferred to a 10 ml screw capped extraction tube. 4ml n-hexane was added to the extraction tube. The mixture was shaken on a vortex mixer for 0.5 min. rested for 5 min. and shaken another 0.5 min. After centrifugation at 4000 rpm for 5min. 1ml of supernatant was transferred to a 1.5 ml vial and evaporated under nitrogen. The residue was re-dissolved in 0.3 ml n-butanol before being injected into Shimadzu HPLC (CRUA: chromatopac. SCL 6A: System controller. CTO 6A: Column oven. SPD 6AV: Uv-vis detector. LC 20AD UFLC: Pump. Mobile phase used was methanol. Flow rate at 1.5 ml /min. Injected (25 µl).
UV (290 nm).

Heat treatment of sesame seeds:

White and Black sesame seeds were placed as single layer in Pyrex dishes in a drying oven for air circulation (Memmert, Germany) and were heated at 60°C for 10 and 15 min. and at 80°C for 10 and 15 min. separately. The heated seeds were cooled to ambient temperature before oil extraction.

Preparation of additatives/tahini blends:

Tahini was obtained from a local factory in kafr el- sheikh that prepared it by using hydraulic press. Blends were prepared by adding lecithin to tahini to give the concentration of 5, 10 and 15% (w/w) and adding carob seeds powder to tahini to give the concentration of 5, 10, 15 and 20% (w/w), and then mixing evenly with a spatula. The levels of the carob seeds powder and lecithin in tahini were selected to represent acceptable range for consumers, then these blends were stored for 3 months ago at room temperature and the separation of oil from tahini paste was observed after 7, 15, 30, 45, 60, 90 days.

Sensory Evaluation:

Sensory evaluation of tahini and tahini with additives (carob seeds powder and lecithin) were evaluated in terms of color, flavor, consistency and overall acceptability using 8 panelists, According to Moskowitz, (1985), using a five point measuring scale (from 1 to 5), where 1 is the least positive and 5 is the most positive response.

Statistical analysis:

The obtained data were subjected to analysis of variance (ANOVA) and Duncan's multiple range test to separate the treatment means. The analysis was computed using the SAS program (Steel and Torrie, 1980). Significance was defined at $P < 0.05$.

RESULTS AND DISCUTION

Proximate chemical composition of sesame seeds:

The proximate chemical composition (protein, fat, moisture, ash, crude fiber and nitrogen free extract) of black sesame (BS) and white sesame (WS) are shown in Table (1): Protein content was found to be higher in WS but lower in the BS (20.91 and 20.14%, respectively). These values are similar to the values reported for benniseed (Dashak and Fali, 1993). The crude fat was observed to be higher in the WS seeds than in BS seeds (56.24 and 52.82%, respectively). Tashiro *et al*. (1990) reported that the oil content ranged from 43.4 to 58.8% for 42 strains of sesame while the highest oil content was found in white-seeded strain. The result of oil content was consistent with the range reported by Tashiro *et al*. (1990). Although Bahkali *et al*. (1998) reported lower oil content in Saudi and Indian sesame seeds ranged from 43.2 to 54.0%. The differences might be attributed to the different regions of seeds production. These results are in accordance with those of Mariod *et al.,* (2011) who found that oil and protein contents were 50% and 25.1%, respectively in unroasted sesame seeds. The moisture content was found to be higher in the BS as compared to the WS (5.56 and 4.44%, respectively). Bahkali *et al*. (1998) reported that the moisture content of different cultivars from different countries was in the range of 3.65-5.60%, which agrees with the results of this study. The ash content was observed to be higher in the WS as compared to the BS (5.61 and 4.95%, respectively). Ozcan and Akgul (1995) reported that ash values were ranged from 3.67 to 5.39% for Turkish and foreign varieties (Mexican, Uganda and Venezuela). Nitrogen free extract was higher in the BS than in the WS (16.49 and 12.44%, respectively). The data were consistent with the results of Elleuch *et al*. (2007).Crude fiber content was higher in the BS than the WS (5.60 and 4.80 %, respectively). Namiki.,(1995) reported that fibers values were between 4 and 5%, sesame seeds which corroborate the result for WS being found within the range but disagree with BS.

Table 1:Chemical composition of raw black and white sesame (based on dry weight):

Components (%)	Black sesame(BS)	White sesame (WS)
Crude protein	20.14 ± 0.11^{b}	20.91 ± 0.09^{a}
Crude fat content	52.82 ± 0.49^{b}	56.24 ± 0.17^{a}
Moisture content	5.56 ± 0.19^{a}	4.44 ± 0.1^{a}
Dry matter	94.44 ± 0.19^{a}	95.56 ± 0.1^{a}
Ash	4.95 ± 0.53^{a}	5.61 ± 0.24^{a}
N. F. E. (by differences)	16.49 ± 0.79^{a}	12.44 ± 0.47^{b}
Crude fiber	5.60 ± 0.09^{a}	4.80 ± 0.08^{b}

• Values are expressed as means of triplicate ±SE

The mineral composition:

The mineral composition of both BS and WS is shown in Table (2): The WS had calcium as the predominant mineral followed by potassium,

phosphorus, magnesium iron, zinc and sodium. With the exception of sodium, zinc and magnesium, the above minerals were higher in quantity than in BS. These results were similar to Elleuch *et al*., (2007) where the mineral elements contents varied between the BS and the WS. This might be attributed to the type of soil where the seeds were grown or perhaps such mineral elements were eliminated during the de-hulling of sesame seed coat, as reported by Johnson *et al*. (1979) that the mineral content of sesame seed is mostly found in the seed coat.

Table 2: The mineral composition of raw black and white sesame seeds:

Mineral element	Unit	White sesame (WS)	Black sesame (BS)
Na	%	0.0044	0.0076
K	%	1.0	0.7
P	%	0.73	0.47
Ca	%	1.08	0.97
Mg	%	0.328	0.362
Fe	mg/kg	372	340
Zn	mg/kg	230.6	289.4

Chemical properties of white sesame seed oils and their changes during heat treatments:

Table (3): shows the values of the chemical properties of the oil extract from crude and heated *Sesamum indicum* L. seeds. The results indicate that the acid value which is an index of free fatty acid content due to enzymatic activity in the samples was found to be very low 0.61 mgKOH/g for white sesame seeds, below the minimum acceptable value of 4.0% for sesame recommended by the Codex Alimentarius Commission for oil seeds (Abayeh *et al.,* 1998). Person. (1981) reported that the acid value of sesame seeds were 0.6 mgKOH/g max. The saponification values of the sesame seeds were found to be within the range of 189 to 195 mg KOH/g, according to Ezeagu *et al.* (1998). Saponification value of 200 mg KOH/g indicates high proportion of fatty acids of low molecular weight. The saponification value of sesame seeds oil from table (3) was 191 mg KOH/g, for raw white sesame seeds. The peroxide value which is an index of rancidity, thus the high peroxide value of oil indicates a poor resistance of the oil to peroxidation during storage. The peroxide value of raw sesame seeds was 1.07 mEq KOH/g for white sesame seeds before heating. The peroxide value of Sesame seeds are far below the maximum acceptable value of 10 mEq KOH/g set by the Codex Alimentarius Commission for groundnut seed oils (Abayeh *et al.,* 1998). The iodine value of the crude sesame oil was 103.2 gI_2/100g oil for raw white seeds, which is high, indicating that it is semi dry oil (Fernando & Akujobi, 1987).

During heating the acid value of the oil extracted from white sesame seeds heated at 60°C for 10 min were 0.63 mg KOH/g and 0.64 mg KOH/g for the oil from heating white sesame seeds at 60°C for 15 min. The acid value for heated white sesame seeds at 80 °C for 10 min was 0.72 mg KOH/g, and then increased to 0.83 mg KOH/g during heating white sesame

seeds at 80 °C for 15 min. No significant differences in saponification values were observed during heat treatment at different temperature for different times. The peroxide value during heating at 60°C for 10 min was 1.14 mEq KOH/g then increased to 1.32 mEq KOH/g after heating at 60°C for 15 min. The lowest degree of peroxide value was 0.73 mEq KOH/g during heating at 80 °C for 10 min then increased twice after heating at 80 °C for 15 min to 0.93 mEq KOH/g. During heating at 60°C for 10 min the iodine value decreased to 102.5 gI_2/100g oil, and then decreased during heating at 60°C for 15 min to 100.73 gI_2/100g oil. Heating at 80°C for 10 min decreased the iodine value to 98.5 gI_2/100g oil, as a matter of fact the iodine value decreased twice during heating at 80°C for 15 min to 97.53 gI_2/100g oil.

Table 3: Chemical properties of sesame seed oils and their changes during heat treatments:

Parameter	Unit	RWS	HWS1	HWS2	HWS3	HWS4
Acid value	MgKOH/g	0.61±0.04 $^{a\,b}$	0.63±0.02 $^{a\,b}$	0.64±0.02 $^{a\,b}$	0.72±0.03 ^{a}	0.83±0.03 ^{a}
Saponification value	MgKOH/g	191±2.40 ^{a}	192.73±3.43 ^{a}	192±2.87 ^{a}	190.55±2.65 ^{a}	191.67±2.52 ^{a}
Peroxide value	mEq/kg	1.07±0.08 ^{bc}	1.14±0.13 ^{bc}	1.32±0.12 ^{b}	0.73±0.02 ^{c}	0.93±0.03 ^{bc}
Iodine value	g I_2/100g	103.2±1.53 ^{b}	102.5±2.59 ^{b}	100.73±0.96 ^{b}	98.5±1.32 ^{bc}	97.53±1.18 ^{bc}

RWS= Raw White Sesame seeds.
HWS1= Heating White Sesame seeds at 60°C for 10 min.
HWS2= Heating White Sesame seeds at 60°C for 15 min.
HWS3= Heating White Sesame seeds at 80°C for 10 min.
HWS4= Heating White Sesame seeds at 80°C for 15 min.
Means with different superscripts in a row are significantly different at P < 0.05.

Fatty acid composition of oil extracted from raw white sesame seeds and their changes during different heat treatments:

Fatty acid composition of the oil extracted from raw white sesame seeds (RWS) is shown in Table (4): The most abundantly found fatty acids were 18:2 (linoleic acid) being 45.68%, followed by 18:1 (oleic acid) 35.83%. Other fatty acids were found in considerable amount are 16:0 (Palmitic acid) 9.15% and 18:0 (stearic acid) 6.90% for RWS. The results obtained are in agreement with those of the literature Teco Finance Export (2005). Compared with the white Sudanese variety studied by Elleuch *et al*. (2007), oleic and linoleic acids contents were lower than the obtained results in linoleic but higher than in oleic. They reported 43 and 35%, respectively, these were in agreement with these results. Also, when compared with the reported results of Yoshida (1994) and Yoshida *et al*. (2000) their results were higher in oleic acid (38%) and linoleic aid (48%). Nonetheless, the content of linolenic acid ω-3 fatty acid, which is beneficial to human health. As observed from the results, the difference in the fatty acid composition might be related to the different origins of the sesame. Another possible reason for such difference might be attributed to the oil extraction method employed for fatty acids analysis in sesame seeds. In general, unsaturated fatty acids, (oleic and linoleic acids) and saturated fatty acids (palmitic and stearic acids) are the most predominant lipid groups observed in the white sesame seeds.

In the present study, the heating temperature applied did not exceed 80°C because in Egypt, the generally applied temperature for sesame roasting is below 65°C. This achievement is valuable for various uses such as meal, paste, confections, and bakery products. However, it are taken under high temperatures should be conducted easily. This achievement is valuable for will be necessary to find other impressive factors indicating fatty acid stability during heating to confirm results from this study. Unsaturated fatty acids of the oil extracted from heating white sesame seeds shown in table(4), were decreased compared with unsaturated fatty acids of the oil extracted from raw white sesame seeds, However the saturated fatty acids were increased during heating. Un saturated fatty acids (USFAs) of the oil extracted from heating white sesame seeds at 60°C for 10 min were the highest percentage (77.74%), however heating white sesame seeds at 80°C for 15 min exhibited the lowest percentage of USFAs (69.46%). Heating seeds (HS) at 80°C for 15 min exhibited the highest percentage of oleic acid (18:1) (48.70%) followed by HS at 80°C for 10 min that was (47.09%) then HS at 60°C for 15 min and HS at 60°C for 10 min.(43.44 and 41.24%), respectively. Heating at 60°C for 10 min showed the highest percentage of linoleic (18:2), followed by HS at 60°C for 15 min that was (36 and 30.11%), respectively, but this acid were decreased in seeds that were heated at 80°C for 10 and 15 min to (23.35 and 20.60%), respectively. Other fatty acids found in considerable amounts were 16:0 (Palmitic acid) 9.66, 10.12, 10.30 and 10.62% in heating seeds at 60°C for10 min, 60°C for15 min, 80°C for10 min and 80°C for15 min, respectively, and 18:0 (stearic acid) 9.75, 13.51, 16.18 and 16.81% in heating seeds at 60°C for10 min, 60°C for15 min, 80°C for10 min and 80°C for15 min, respectively.

Table 4: Fatty acid composition of oil extracted from raw white sesame seeds and their changes during different heat treatments:

Fatty acid	RWS	HWS1	HWS2	HWS3	HWS4
C16:0	9.15	9.66	10.12	10.30	10.62
C18:0	6.9	9.75	13.51	16.18	16.81
C18:1	35.83	41.24	43.44	47.09	48.70
C18:2	45.68	36.00	30.11	23.35	20.60
Others	1.99	2.68	2.52	2.22	2.16
SFAs	18.4	22.53	26.31	29.38	30.54
USFAs	81.6	77.47	73.69	70.62	69.46

RWS = Raw white sesame seeds.
HWS1= Heated white sesame seeds at 60°C for 10 min.
HWS2= Heated white sesame seeds at 60°C for 15 min.
HWS3= Heated white sesame seeds at 80°C for 10 min.
HWS4= Heated white sesame seeds at 80°C for 15 min.

Total phenol and total lignans content in white sesame seeds and their changes during heat treatments:

Total lignans in the white seeds were about 2.5 % (table 5). In confirmation with a previous study, these results suggest that sesame seed may be a rich source of lignans as flaxseed (Moazzami and Kamal-Eldin,

2006), which reported that the total content of native lignans in sesame seeds was in the range of 224–1148 mg/ 100g seed Since sesame seeds are consumed as food to a much larger extent than flaxseed, their oil might provide the richest sources of dietary lignans.

Sesame seeds have been recognized to possess several medicinal properties and have been effectively used in India and other countries. Apart from the traditional use, many beneficial physiological effects have been brought to the fore by extensive studies (Anilakumar et al. 2001, Khanum and Anilakumar 2004). Hence this study was taken up to evaluate the comparative effects of white sesame seed extracts for their antioxidant activities. The yield of ethanolic extract of white sesame seeds in powder form was found to be 107.11 mg/kg. This result was agreement with the result reported by (Awatif *et al*., 2013), which was 108.12 mg/kg.

Kim (2000) reported that the storage stability of unroasted sesame oil was low, but roasting of sesame seed at 170°C or higher significantly increased the stability of sesame oil.

In this study, total phenol contents (TPC) of heated white sesame seeds at 60°C for 10 min were increased to 132.64 mg/ kg as Gallic acid equivalent, after heating at 60°C for 15 min total phenols increased to 146.27 mg/kg, but during heating at 80°C for 10 min and 15min, total phenols decreased to 75.39 and 72.54 mg/kg, respectively. These results suggests that the total polyphenols were found to increase after heat treatment at 60°C for 10 and 15 min, rather that at 80°C for the same time. Awatif *et al*., (2013) reported that the levels of total polyphenols were found to increase after roasting.

During heating at 60°C for 10 min total lignans of white sesame seeds decreased to 1.9%, then increased to 2.7% after heating at 60°C for 15 min. Total lignans of white sesame seeds recorded the highest ratio after heating at 80°C for 10 min (3.8%), then this ratio decreased to 1.8% after heating at 80°C for 15 min. Fukuda *et al*., (1986) reported that epimerization of the sesame oil lignans happens in the presence of heat, in which eppisesamin and episesaminol are formed.

Table 5:Total phenols and lignans contents in white sesame seeds and their changes during heat treatments:

Treatments	Lignans (%)	Total phenols (mg/kg of Gallic acid)
WS	2.5	107.11
HWS1	1.9	132.64
HWS2	2.7	146.27
HWS3	3.8	75.39
HWS4	1.8	72.54

WS= Raw white sesame seeds.
HWS1= Heated white sesame seeds at 60°C for 10 min.
HWS2= Heated white sesame seeds at 60°C for 15 min.
HWS3= Heated white sesame seeds at 80°C for 10 min.
HWS4= Heated white sesame seeds at 80°C for 15 min.

Tocopherols in white sesame seeds oil and their changes during heat treatments:

Apart from sesame lignans, sesame seed and oil also contain other important biologically active compounds, such as vitamin E (tocopherol homologues), especially γ-tocopherol (Hemalatha &Ghafoorunissa, 2004 and Williamson *et al*., 2008). Vitamin E occurs naturally as eight structurally related forms that include four tocopherols (α-, γ-, δ-, β-tocopherols) and four tocotrienols (α-, γ-, δ-, β-tocotrienols) (Dietrich *et al.*, 2006).

α-Tocopherol is the only form of vitamin E in vitamin supplements whereas γ-tocopherol is the predominant form of vitamin E in the US diet (Jiang *et al*., 2001). γ-Tocopherol has many beneficial properties, such as antiproliferative effects in human cancer cells, e.g. prostate cancer and breast cancer (Guthrie *et al*., 1997 and Gysin *et al*., 2002), anti-inflammatory activity (Jiang & Ames, 2003) and partial prevention of age-associated transcriptional changes in heart and brain of mice (Park *et al*., 2008). In addition, Cooney *et al*., (2001) found that the consumption of moderate amounts of sesame seeds appeared to significantly increase plasma γ-tocopherol and alter plasma tocopherol ratios in humans.

Total tocopherols of white sesame seeds are shown in Table (6): which was 52.58 mg/100gm. The total tocopherol content of sesame oil ranges from 330-mg/kg to 1010-mg/kg oil according to the Codex Standard, while Hui (1996) reported that Vitamin E (mg/l00g) in sesame seeds is 29.4-52.8. During heating at 60°C for 10 min the tocopherols increased to 65.95 mg/100gm; however the highest content of tocopherols was found in heated white sesame seeds at 60°C for 15 min being (68.86 mg/100gm). Tocopherols were decreased at heating at 80°C for 10 min and heating at 80°C for 15 min to (58.62 and 18.96 mg/100gm, respectively., this may be due to some degree of oxidation and polymerization of tocopherols (Lea and Ward., 1959). Mariod *et al.,* (2011) reported that the primary tocopherol of sesame oil was γ-tocopherol (63.32 mg / 100g) of the total tocopherols.β and δ-tocopherols were found at trace levels below 1 mg/100g.Tocopherols are fat soluble antioxidants that function as scavengers of lipid peroxyl radicals (Knekt *et al.,* 1994). Mixed tocopherols had a better antioxidant and anti-inflammatory effects in animal model (Saldeen and Saldeen, 2005).

Table 6: Total tocopherols of white sesame seeds oil and their changes during differences conditions of heating:

Component	WS	HWS1	HWS2	HWS3	HWS4
Total tocopherols (mg/100gm)	52.58	65.95	68.86	58.62	18.96

WS= Raw white sesame seeds.
HWS1= Heated white sesame seeds at 60°C for 10 min.
HWS2= Heated white sesame seeds at 60°C for 15 min.
HWS3= Heated white sesame seeds at 80°C for 10 min.
HWS4= Heated white sesame seeds at 80°C for 15 min.

Sensory Evaluation:

Lecithin and carob seeds powder were added to tehina from white sesame seeds at different levels (5, 10, 15%) and (5, 10, 15, 20%), respectively, to decrease the separation of oil that might take place in tehini paste. Results in table (7) indicated that no significant differences in colour were observed when we added lecithin and carob seeds powder at different levels. Concerning flavour no significant differences were observed by the panelists when adding these additatives at different levels except for carob seeds powder at 15 and 20% which exhibited significant lower scores but still acceptable. Results showed no significant difference in consistency at different levels due to the addition of lecithin and carob seeds powder at all levels. Nevertheless the tahina with added carob seeds powder had overall acceptability at different levels as compared to tahina with lecithin.

Results showed that by adding carob seeds powder to white tehina at (5, 10, 15 and 20%) significantly delayed separation time up to 7, 25, 45 and 60 days, respectively., while by adding lecithin at (5, 10 and 15%) significantly delayed separation time up to 7, 25 and 30 days, respectively.

Table 7: Mean sensory scores of white tehini with lecithin and carob seeds powder at different levels:

Parameter / Treatment	Control	Lecithin			Carob seeds powder			
		5%	10%	15%	5%	10%	15%	20%
Colour	4.50±0.19^{a}	4.13±0.13^{a}	4.38±0.18^{a}	4.13±0.13^{a}	4.38±0.26^{a}	4.38±0.26^{a}	4.50±0.19^{a}	4.13±0.13^{a}
Flavour	4.63±0.26^{a}	4.38±0.26^{a}	4.25±0.25^{a}	4.38±0.26^{a}	4.50±0.19^{a}	4.13±0.30^{a}	3.50±0.19^{b}	3.25±0.31^{b}
Consistency	4.38±0.32^{ab}	3.88±0.23^{b}	4.25±0.16^{ab}	4.25±0.25^{ab}	4.38±0.26^{ab}	4.00±0.33^{ab}	4.50±0.27^{ab}	4.63±0.26^{a}
Overall acceptability	3.88±0.44^{bc}	3.63±0.38^{c}	3.88±0.35^{bc}	4.00±0.33^{abc}	4.50±0.19^{ab}	4.13±0.23^{abc}	4.63±0.26^{a}	4.38±0.32^{ab}

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تـأثير بعـض المعـاملات الحراريـه علـى التركيـب الكيمـاوى وخـواص زيـت بـذور السمسم

أحمـد محمـد أبوخشبه[١]، أميمـه السيد شلتوت[٢] ، إنتصـار عبـد المحسـن الـدفراوى[٢] ،أيمن محمد أبواليزيد[٢] و محمد السيد إسماعيل الصردى[١].

١- قسم بحـوث الزيـوت والـدهون- معهـد بحـوث تكنولوجيـا الأغذيـة- مركـز البحـوث الزراعيـة- الجيزه.

٢- قسم علوم الأغذية- كلية الزراعة- سابا باشا- جامعة الإسكندريه- الإسكندريه.

أجرى هذا البحث بهدف دراسة التركيب الكيماوى لبذور السمسم البيضاء والداكنه الخام، وبعض الصفات الكيماويه للزيت المستخلص من البذور البيضاء قبل وبعد المعاملة الحرارية على ٦٠& ٨٠ °م لمدة ١٠ و ١٥ دقيقه . كما تم تقدير المركبات النشطه حيويا لبذور السمسم البيضاء والداكنه والتى تشمل مركبات اللجنان ، والفينولات الكليه ، والتوكوفيرولات ثم تم تقديرها فى البذور البيضاء بعد المعامله الحراريه. وأوضحت النتائج أن كلتا بذور السمسم الداكنه والبيضاء تحتوى على نسبه مرتفعه من الزيت (٥٢,٨٢ &٥٦,٢٤٪) والبروتين (٢٠,١٤ & ٢٠,٩١ ٪) على الترتيب. كما أوضحت النتائج أن بذور السمسم تعد مصدر جيد للمعادن حيث وجد أن الكالسيوم يمثل أعلى معدن من المعادن التى تم تقديرها فى بذور السمسم الداكنه والبيضاء (٠,٩٧ & ١,٠٨ ٪) وكذلك وجود الحديد والزنك ولكن بنسب متقاربه فى كلا البذورحيث كانت (٣٧٢ و ٢٣٠,٦ مجم/ كجم) بالنسبة للبذور البيضاء وكانت (٣٤٠ و ٢٨٩,٤ مجم/ كجم) بالنسبة للبذور الداكنه، على الترتيب. ويعتبر حامض البالمتيك هو الحامض الدهنى المشبع السائد بينما يعتبر حامض اللينوليك هو الحامض الدهنى غير المشبع السائد فى البذور الخام والمعامله حراريا، وبعد إجراء المعاملات الحراريه على ٦٠ و ٨٠ °م لمدة ١٠ و ١٥ دقيقه زادت الأحماض الدهنيه المشبعه وانخفضت الأحماض الدهنيه غير المشبعه.

تم إضافة الليسيثين وبذور الخروب المطحونه إلى الطحينه المصنعه من بذور السمسم البيضاء بمستويات مختلفه (٥ ،١٠ ، ١٥ ٪) وزيدت نسبة بذور الخروب إلى (٢٠ ٪) وذلك لتقليل ظاهرة فصل الزيت من الطحينه عند التخزين. وأظهرت النتائج أن إضافة بذور الخروب بمستويات (١٥ & ٢٠ ٪) أدت إلى تأخير ظاهرة الفصل لمده تصل إلى ٤٥ و ٦٠ يوم على التوالى وذلك مقارنة بالطحينه الخام والتى فصلت خلال أسبوع فقط.