

Chemical Characteristics and Oxidative Stability of Sesame Seed, Sesame Paste, and Olive Oils

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ABSTRACT

Raw (intact) sesame seed showed a high content of oil, protein and ash: respectively, 52%, 24% and 5%. Studies were conducted on some quality characteristics of sesame and olive oils. The following values were obtained from raw sesame, sesame paste and olive oils, respectively: unsaponifiable matter 1.35, 1.46, and 1.50%; total phenols 14.21, 16.82, and 53.33 mg kg⁻¹ oil; chlorophylls 0.04, 0.09 and 1.88 µg g⁻¹; carotene 2.62, 3.66 and 19.10 µg g⁻¹; refractive index 1.47, 1.47 and 1.47; saponification value 186.6, 185.75, and 97.94; iodine value 113.35, 91.34, and 81.23, acidity along with of 1.64, 1.10, and 1.12 mg KOH g⁻¹ oil. Fatty acid profiles of raw sesame, sesame paste and olive oils showed a predominance of oleic acid (41.68%, 41.94%, and 52.14%, respectively) followed by linoleic-acid (38.29%, 37.48%, and 17.82%). Storage effect at 65°C of raw sesame, sesame paste and olive oils were later on studied. Results showed that the oxidative stability of raw sesame oil was higher than that of sesame paste oil. Due to its all favorable properties, sesame oil could be used in either food or cosmetic products.

Keywords: Raw sesame oil; Sesame paste oil; Olive oil; Quality characteristics; Oxidative stability

INTRODUCTION

Since millennia, sesame (*sesamum indicum* L.) had has a highly important place in human food. This product has been used as an essential constituent in different recipes (Xu *et al.*, 2005). Archeological records indicate that it has been known and used in India for more than 5,000 years and is recorded as a crop in Babylon and Assyria some 4,000 years ago (Were *et al.*, 2006).

Sesame powder had also been used throughout East Africa where it is mainly grown for grain and oil (Were *et al.*, 2006). So, many countries produce and export this product, mainly China, Japan, India, Cameroon, Egypt, Senegal, Brasilia and Iran (Abou Gharbia *et al.*, 1997; Chang *et al.*,

2002; Rajaei *et al.*, 2008; Shahidi *et al.*, 1997). As for Tunisia, 80% of the needed sesame seed is imported from Sudan and 20% from Egypt (Anonymous, 2005).

Sesame seed is an essential material to manufacture "Halwa Chamia" which was prepared from "Tahina" and from Nougat; with an addition of some such flavoring ingredients as vanilla and walnut. "Tahina" is a paste exclusively elaborated from milled and decorticated sesame seed (Abu Jdayil *et al.*, 2002; Alpaslan and Hayta, 2002; Razavi *et al.*, 2007). 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%). The oil fraction shows a remarkable stability to oxidation. This could be attributed to endogenous antioxidants namely lignins and

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tocopherols (Elleuch *et al.*, 2007; Lee *et al.*, 2008). In general, sesame oil 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; Uzun *et al.*, 2002; Weiss, 1983). However, fatty acid composition as well as oil content are influenced by various physiological, ecological and cultural factors (Uzun *et al.*, 2002).

Oxidative stability of sesame oil is higher in case of the oil extracted from coated seeds than in that extracted from dehulled seeds (Abou-Gharbia *et al.*, 1997; Elleuch *et al.*, 2007). Storage test, e.g. shelf-life test or oven test could be employed to study physico-chemical changes in edible oils (Nissiotis and Tasioula, 2002; Vieira and Regitano d'Arce, 2001), but they require time before the results are taken. The uses of sesame and olive oils as natural antioxidants have been reported (Fazel *et al.*, 2008; Koprivnjak *et al.*, 2008; Nissiotis and Tasioula-Margari, 2002; Rajaei *et al.*, 2008; Sahari *et al.*, 2004).

In this context, the properties of sesame as well as sesame paste oils were compared with a commercially obtained virgin olive oil used in manufacturing, food, cosmetics, and in pharmaceutical industries.

The aim of the present work is to evaluate the physico-chemical composition of raw sesame seeds, as well as to determine fatty acid profile, physical profiles and oxidative stability of oils obtained from sesame seed, sesame paste and from olive oils.

MATERIALS AND METHODS

Samples

White Sudan sesame seed (*S. indicum* L.) as well as sesame paste were gratefully provided by Triki Candy (Gabes-road Km 3 Sfax, Tunisia). The sesame paste had been prepared from ground, dehulled and dry roasted sesame seeds.

A commercial olive oil, with no antioxidant addition, was purchased from an

olive oil mill in Sfax region. The chain system was operating in continuous. The obtained olive oil was stored in a freezer (-20°C) for subsequent analysis.

Oil Extraction and Preservation

Sesame seeds were washed in abundant water before being drained on a sieve, dried in an oven at 40°C, and then milled in a mechanical grinder to obtain paste.

Raw sesame and sesame paste (150 g) were placed in dark flasks (capacity= 1 l) and homogenized with 750 ml hexane (1:5, m:v). The mixture was maintained under agitation for a period of one night. Hexane was separated through vacuum filtration. The extracts were undergone evaporation using a rotary evaporator at 40°C. The obtained oil was drained under a stream of nitrogen and then stored in a freezer (-20°C) until time for analysis.

Analytical Methods

All the analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean±standard deviation (±SD). Dry matter was determined according to the Association of Official Analytical Chemists (AOAC, 1990). Water activity (aw) was measured at 25°C through a Novasina Aw Sprint TH-500 apparatus. To remove carbon, about 2 g (powdered) of sample, in a porcelain container, was ignited and incinerated in the muffle furnace at about 550°C for 8 hours. Total ash was expressed as percent of dry weight (AOAC, 1995). The mineral constituents (Ca, Na, K, Mg and Fe) present in the sesame seeds were analyzed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Japan) (AOAC, 1990). Total protein was determined through Kjeldhal method. Protein was assessed using the general factor (6.25). Data was expressed as percent of dry weight (AOAC, 1995). The determination of

the content of starch was achieved through colorimetry. After removal of sugars by use of ethanol (80%), starch was isolated by extraction with perchloric acid reagent (52%) twice, from a sugar-free residue according to the method described by McCready *et al.* (1950). Starch in the extract was determined using Anthrone reagent and colorimetric measurement at 630 nm. The concentration of starch was calculated in mg of glucose \times 0.9 (McCready *et al.*, 1950). Fat content was determined by Soxhlet extraction with petroleum ether at boiling point of the solvent (40-60° C) (Merck, for analysis). This extraction (Soxhlet method) was carried out to estimate oil content.

Analysis of Oils

AOCS official methods (AOCS, 1997) were employed for the determination of the unsaponifiable matter (Method Ca 6b-53), acidity (method Cd 3d-63) and iodine value (method Cd 1-25). The refractive index was determined using an Abbe refractometer (Bellin-ghan, and Stanley Ltd, United Kingdom) at 20°C (AOAC, 1990).

Methyl esters are obtained by methanolysis in alkaline environment according to the method described by Wolff (1968). GC analyses were performed on a Hewlett-Packard 5890 Series II gas chromatograph (H.P.Co., Amsterdam, The Netherlands) equipped with a flame hydrogen ionization detector and a capillary column (HP Inovax cross-linked PEG, 30 m \times 0.25 mm \times 0.25 μ m film). The column oven temperature was programmed from 180 to 280°C at 10°C min⁻¹. The injector and detector temperature were set at 250°C. The carrier gas was helium at a flow rate of 1 ml min⁻¹. The identification of the peaks was achieved by retention times and by comparing them with authentic standards purchased from Sigma and analysed under the same conditions. Peak areas of triplicate injections were measured with an HP computing integrator.

The Cie Lab coordinates (L^* , a^* , b^*) were directly read with a spectrophotocolorimeter (Tintometre, Lovibond PFX 195 V 3.2, Amesbury, UK). In this coordinate system, the L^* value is a measure of lightness, ranging from 0 (black) to 100 (white), the a^* value ranges from -100 (greenness) to +100 (redness) and the b^* value ranges from -100 (being blue) to +100 (yellowness).

Chlorophyll content (mg kg⁻¹) was quantified by spectrophotometry according to AOCS (1997) method Cd 13d-55.

Carotenoid content was measured according to the method described by Minguez *et al.* (1991). The absorbency measure of 7.5 g of oil dissolved in 25 ml of cyclohexane was realised at 470 nm. Carotenoid content was calculated using Equation (1) namely: "*Carotenoid content* = $(A_{470} \times 25 \times 10000) / (E_0 \times 7.5)$ " in which, A_{470} : Absorption maximum at 470 nm; E_0 : Specific extinction (2000).

Total phenols, expressed as caffeic acid (μ g g⁻¹ of oil) were determined at 725 nm using Folin-Ciocalteu reagent as described by Salvador *et al.* (2003). Sesamol was isolated by extraction with potassium hydroxide solution (potassium hydroxide: ethanol:water, 10:20:80, w/v/v) three times, from an oil-in-isooctane using a separatory funnel according to the method described by Budowski *et al.* (1950). Sesamol was determined in the extract using a furfural solution and colorimetric measurement at 518 nm (Budowski *et al.*, 1950). Oven test was used to evaluate the oxidative stability for the oil fractions. Oil samples (70 g) were kept in equal portions in open flasks (30 ml capacity, 30 mm diameter and 70 mm height) in the dark in an oven (Binder, No: 970465, Tuttlinger, Germany) at 65°C for 45 days. The resistance against oxidation was evaluated by the peroxide value (PV) in which: 1 \pm 0.1 g of each oil sample was weighed and subjected to iodometric determination according to Cd 1-25 method (AOCS, 1997). Specific absorptivity at 232 and 270 nm were calculated from absorption at 232 and 270 nm, respectively, with a UV spectrophotometer (SECOMAN, Type:



ANTHELIE 70 MI 0291, No: 344, Domont, France) using a 1% solution of oil in cyclohexane and path length of 1 cm (AOAC, 1997). Viscosity was followed at 20°C with a Stress Tech Rheologica Rheometer (reologica instruments AB, Lund, Sweden) conducted with a steel cone-plate (C40/4) under a constant shear rate of 100 s⁻¹.

Statistical Analysis

Data were analysed using the Statistical Package for the Social Sciences "SPSS" (Version 13), and Duncan test was used to compare differences among means. Significance was defined at P< 0.05.

RESULTS AND DISCUSSION

Physico-chemical Composition of Raw Sesame Seed

Table 1 shows the dry matter in raw sesame seed was high (~96%). Concerning water activity, the found value (0.507) shows a scant availability of water. An activity under 0.6 excludes any possibility of microbial development. In fact, it's mainly the yeasts or the moulds which could be multiplied at water activity under 0.7 (El-Gerssifi, 1998).

Raw sesame contained ~53% of oil. This confirms previous findings by Al-Adawy and Mansour (2000) who reported a high content of oil for the dehulled sesame seeds

Table 1. Chemical composition (g 100 g⁻¹ of dry matter basis) and water activity of raw sesame seeds.

Component	Raw sesame seeds
Dry matter (%)	95.55 ± 0.04
Water activity	0.51 ± 0.01
Protein	24.63 ± 0.11
Oil	52.67 ± 0.14
Starch	0.05 ± 0.01
Ash	5.44 ± 0.03
Calcium (Ca)	0.16 ± 0.04
Magnesium (Mg)	0.10 ± 0.01
Sodium (Na)	0.01 ± 0.01
Potassium (K)	0.17 ± 0.04
Fer (Fe)	0.04 ± 0.01

(58.9%). Protein content in raw sesame was high (~25%) reminding one of other foodstuffs rich in proteins such as almond, hazelnut protein the contents of which were respectively, 20% and 21% (Nanos *et al.*, 2002; Ozdemir and Akinci, 2004).

The ash content in raw sesame was relatively high (~5%) compared to other products of great consumption such as almond (3%), and the pistachio (2.7%) (Woodroof, 1979). The mineral composition of raw sesame showed that potassium was the predominant mineral (~0.17%) followed by calcium (~0.16%) and magnesium (~0.10%).

Physico-chemical Profiles of Oils

Characteristics Index

Table 2 presents the physico-chemical quality parameters of raw sesame, sesame paste and olive oils. The refraction index is characteristic of the group to which belongs the fatty corpse. It is directly related to the acidic composition of oils (free fatty acid, unsaturation degree, length of hydrocarbon chains) and to their status of oxidation. There was no significant difference (P> 0.05) observed between raw sesame, sesame paste and olive oils (Table 2). Sesame oil could be classified in the group of semi-siccative oils, such as cotton, corn, colza and soya oils. The refractive index of raw sesame and sesame paste oils was similar to that reported by Elleuch *et al.* (2007), but relatively higher than that of other oils (date seed oil, virgin olive oil, *Moringa oleifera* seed oil) (Barminas *et al.*, 1999; Besbes *et al.*, 2004; Lalas and Tsaknis, 2002). This difference could be explained by a different acidic composition and by a less intensified coloration.

Raw sesame and sesame paste oils had a relatively low content of the Free Fatty Acids (FFA) ranging between 0.55% and 0.82%. These values were comparable to

Table 2. Physico-chemical characteristics of raw sesame seed, sesame paste and olive oils.

Determination	Raw sesame oil	Sesame paste oil	Olive oil
Acid value (mg KOH g ⁻¹ oil)	1.64 ± 0.02 ^b	1.10 ± 0.02 ^a	1.12 ± 0.06 ^a
Free fatty acids (as Oleic acid %)	0.82 ± 0.01 ^b	0.55 ± 0.01 ^a	0.56 ± 0.04 ^a
Peroxide value (meq O ₂ kg ⁻¹ oil)	0.14 ± 0.01 ^a	0.19 ± 0.02 ^a	0.99 ± 0.04 ^b
Iodine value (g of I ₂ 100 g ⁻¹ of oil)	113.35 ± 0.59 ^c	91.34 ± 0.43 ^b	81.23 ± 0.40 ^a
Saponification value (mg KOH g ⁻¹ oil)	186.60 ± 0.59 ^b	185.75 ± 0.43 ^b	97.94 ± 0.24 ^a
Refractive index (at 20 °C)	1.471 ± 0.001 ^a	1.471 ± 0.001 ^a	1.471 ± 0.001 ^a
Unsaponifiable matter (µg/g)	1.35 ± 0.40 ^a	1.46 ± 0.45 ^a	1.50 ± 0.60 ^a
Polyphenols (as mg caffeic acid kg ⁻¹ oil)	14.21 ± 0.20 ^a	16.82 ± 0.30 ^b	53.33 ± 0.55 ^c
Sesamol (µg g ⁻¹)	6.09 ± 0.35	8.51 ± 0.70	-
Chlorophyll (µg g ⁻¹)	0.04 ± 0.03 ^a	0.09 ± 0.08 ^a	1.88 ± 0.15 ^b
Carotene (µg g ⁻¹)	2.62 ± 0.10 ^a	3.66 ± 0.25 ^a	19.10 ± 0.40 ^b

Means within the same row with different letters are significantly different (P < 0.05); ±S.D.

those of olive oil (0.56%). This reveals a proper stability during extraction as well as during storage; making it possible to incorporate sesame oil in the foodstuffs or make use of it in pharmaceutical applications.

Raw sesame and sesame paste oils showed high iodine values. In fact, the iodine values of raw sesame and sesame paste oils were 113.35 and 91.34 g of I₂ 100 g⁻¹ oil, respectively. These values were higher than that in olive oil (81.23 g of I₂ 100 g⁻¹ oil). This result indicates that these oils are non-drying, highly unsaturated and it suggests that they contain high levels of oleic and linoleic acids (Elleuch *et al.*, 2007). Abou-Gharbia *et al.* (1997) reported similar iodine values in fresh oils prepared from raw sesame seeds of an Egyptian variety (111.7 g of I₂ 100 g⁻¹ oil). There were a significant differences (P < 0.05) observed in iodine values between raw sesame and sesame paste as well as olive oils.

The peroxide values of raw sesame and sesame paste oils were lower than those of olive oil (0.14 and 0.19 against 0.99 meq O₂ kg⁻¹ oil). This may be due to the higher stability of raw sesame and sesame paste oils during the extraction operations (Besbes *et al.*, 2004).

The saponification values of raw sesame and sesame paste oils were higher than those of olive oil (186.6 and 185.8 against 97.9 mg of KOH g⁻¹ oil). These values were comparable to Aleppo pine seed oil (190 mg

of KOH g⁻¹ oil), raspberry oil (191 mg of KOH g⁻¹ oil), safflower oil (191.6 mg of KOH g⁻¹ oil) and grape seed oil (192.9 mg of KOH g⁻¹ oil) (Cheikh-Rouhou *et al.*, 2006; Oomah *et al.*, 2000). There were no significant variations observed between raw sesame and sesame paste oils in saponification values.

Regarding the unsaponifiable matter, there was no significant difference observed (P > 0.05) between raw sesame, sesame paste and olive oils. The unsaponifiable matter of raw sesame and sesame paste oils was comparable to those in other vegetable oils (Karleskind and Wolf, 1996).

Olive oil showed high total phenol contents as compared to raw sesame and sesame paste oils (53.33 against 14.21-16.82 mg as caffeic acid kg⁻¹ oil). These total phenol contents were higher than those of such other oils as coriander seed oil and niger seed oil as reported by Ramadan and Mörsel (2004) (between 5 and 11 mg kg⁻¹ oil). Indeed, the level of phenol in seed oils is an important factor when assessing the quality of oil because these compounds have been correlated with colour and the shelf-life of oil, and particularly its resistance to oxidation (Cheikh-Rouhou *et al.*, 2006).

Sesamol is a potent phenolic antioxidant (Budowski *et al.*, 1950; Yoshida *et al.*, 1995; Yoshida and Takagi, 1997). It was detected in low amounts in raw sesame and sesame paste oils (6.09-8.51 mg kg⁻¹ oil). This amount was much higher than that reported



by Mohamed and Awatif (1998; 0.2 mg kg⁻¹ oil), but lower than that reported by Budowski *et al.* (1950; 10 mg kg⁻¹ oil) using the same colorimetric methods. This difference may be due to extraction techniques of oil, environmental and ecological characteristics of the particular growing area (Elleuch *et al.*, 2007). Yoshida and Takagi (1997) reported a sesamol content of 5.1 mg kg⁻¹ oil using chromatographic method. Recently, Elleuch *et al.* (2007) found that sesamol content was 8.11 mg kg⁻¹ oil. Indeed, sesame oil contains sesamol, sesamin and sesamolin which decreased the autoxidation of oil at a relatively low temperature (Lee *et al.*, 2008). The sesamol is a typical phenol component of sesame oil. It is formed by sesamoline hydrolysis during the thermal oxidation (Chang *et al.*, 2002; Mohamed and Awatif, 1998). Kajimoto *et al.* (1992) reported that this component has an important preventive effect against the thermal decomposition of tocopherol.

Chlorophyll and carotenoids are important quality parameters because they correlate with colour, which is a basic attribute for evaluating oil quality (Salvador *et al.*, 2001).

Olive oil contained slightly more chlorophyll and carotene than raw sesame and sesame paste oils (1.88 µg g⁻¹ against 0.04-0.09 µg g⁻¹ and 19.10 µg g⁻¹ against 2.62-3.66 µg g⁻¹). There was no significant

variation observed in chlorophyll and carotene contents between raw sesame and sesame paste oils.

Fatty Acid Composition

Fatty acid composition of the extracted oils from raw sesame, sesame paste and olive is presented in Table 3. The most abundant fatty acids were oleic acid (respectively, 41.68, 41.94, and 52.14%), linoleic acid (respectively, 38.29%, 37.48%, and 17.82%), palmitic acid (respectively, 12.96%, 12.75%, and 22.60%), and stearic acid (respectively, 5.76%, 5.88%, and 2%). The linoleic acid, peanut acid and gadoleic acid were of very low rates. There occurred no significant changes ($P > 0.05$) in fatty acid composition as regards a comparison between raw sesame and sesame paste oils. The fatty acid composition of raw sesame oil was within the range of the results reported by Elleuch *et al.* (2007); Mohamed and Awatif (1998); Uzun *et al.* (2002) and Weiss (1983). The raw sesame and sesame paste oils contained considerable contents of mono unsaturated fatty acids (respectively, 42.05%, 42.35%), mainly oleic acid. Monounsaturated fatty acid characteristic of olive oil (56.03% of total fatty acids) could have a hypocholesterolemic effect (Vieira and Regitano d'Arce, 2001).

Table 3. Fatty acid composition (%) of raw sesame seed, sesame paste and olive oils.

Fatty acid	Raw sesame oil	Sesame paste oil	Olive oil
Palmitic (C16:0)	12.96 ± 0.06 ^a	12.75 ± 0.00 ^a	22.60 ± 0.08 ^b
Palmitoleic (C16:1)	0.22 ± 0.01 ^a	0.24 ± 0.02 ^a	3.74 ± 0.03 ^b
Stearic (C18:0)	5.76 ± 0.06 ^b	5.88 ± 0.03 ^b	2.00 ± 0.04 ^a
Oleic (C18:1)	41.68 ± 0.61 ^a	41.94 ± 0.31 ^a	52.14 ± 0.05 ^b
Linoleic (C18:2)	38.29 ± 0.24 ^b	37.48 ± 0.14 ^b	17.82 ± 0.19 ^a
Linolenic (C18:3)	0.48 ± 0.02 ^a	0.53 ± 0.00 ^a	0.93 ± 0.00 ^b
Arachidic (C20:0)	0.53 ± 0.01 ^b	0.58 ± 0.02 ^b	0.30 ± 0.00 ^a
Eicosenoic (C20:1)	0.15 ± 0.03 ^a	0.17 ± 0.02 ^a	0.15 ± 0.00 ^a
SAFA	19.25 ± 0.13	19.21 ± 0.05	24.90 ± 0.12
MUFA	42.05 ± 0.65	42.35 ± 0.35	56.03 ± 0.08
PUFA	38.77 ± 0.26	38.01 ± 0.14	18.75 ± 0.19

Means within the same row with different letters are significantly different ($P < 0.05$); ±S.D.

SAFA: Saturated Fatty Acids, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids.

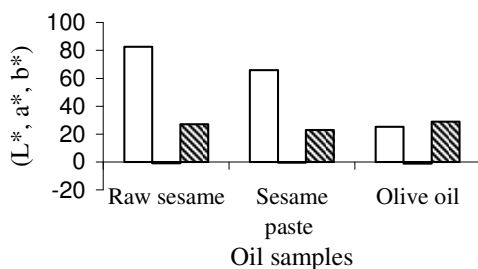


Figure 1. Cie Lab coordinates (L^* , a^* , b^*) of raw sesame oil, sesame paste oil, and olive oil (L^* :□, a^* :■, b^* :▨).

Colour

Cie Lab coordinates (L^* , a^* , b^*) of the oil extracted from the raw sesame seed, sesame paste and olive oils are shown in Figure 1. Raw sesame oil exhibited higher L^* , a^* and b^* values. This means that raw sesame oil was lighter, more red and yellow-coloured than sesame paste oil. Elleuch *et al.* (2007) studied Cie Lab coordinates (L^* , a^* , b^*) of the oil extracted from raw sesame and its by-products, and reported that dehulling as well as roasting causes an increase in the dark, red and yellow units of colour. The colour formation in sesame oil during heat treatment is probably due to non enzymatic browning (Maillard reaction) that occurs during roasting.

Furthermore, olive oil was darker and

yellowier than raw sesame and sesame paste oils. This colour would probably be due to the presence of carotenoids, colouring substances currently used in the industries of fatty corpses.

The value of the coordinates of Cie Lab (L^* , a^* , b^*) of such other vegetable oils as palm oil, soya seed, sunflower, olive and corn oils vary, respectively, from 63.4 to 69.5; from 3.8 to 4.4 and from 9.2 to 10.45 (Hsu and Yu, 2002).

Thermal Oxidation at 65°C

Such quality indexes as specific extinctions at 232 and 270 nm, peroxide value and viscosity were followed up in order to study the effect of storage in accelerated conditions (oven test at 65°C) on raw sesame seed, sesame paste and olive oils.

Figure 2 illustrates the change in absorptivity at 232 nm during the storage period at 65°C. The initial conjugated diene value of olive oil was lower than those of oils extracted from raw sesame and sesame paste (1.92, 2.90 and 3.11 for olive oil, raw sesame oil and sesame paste oil, respectively). The formation of primary compounds of oxidation such as hydroperoxides is accompanied by increase in absorptivity at 232 nm. The formation of primary compounds of oxidation proceeded initially at a lower rate. Indeed, the absorptivity at 232 nm passed from 2.9 to

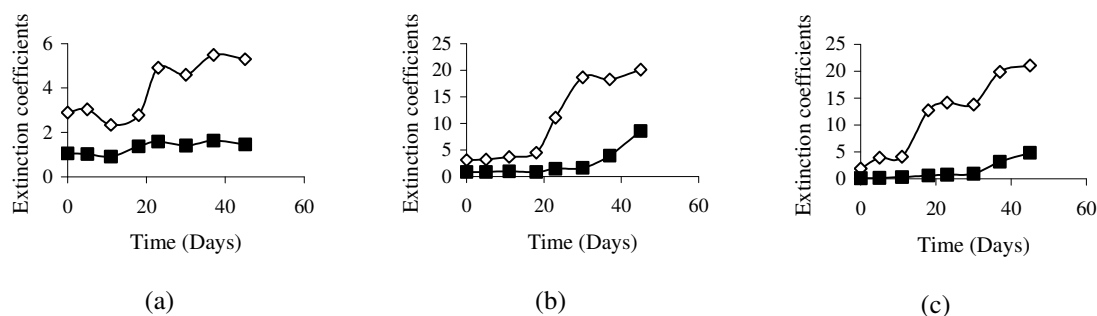


Figure 2. Change in specific extinctions at 232 nm (◇) and at 270 nm (■) during storage period at 65°C of raw sesame, sesame paste and olive oils. (a): Raw sesame oil; (b): Sesame paste oil, (c): Olive oil.



3.04, 3.11 to 3.22 and 1.92 to 3.92 for raw sesame, sesame paste and olive oils, respectively. This little increase could be explained by the resistance of oils to oxidation. After 45 days, sesame paste and olive oils presented much higher absorptivity at 232 nm as compared to raw sesame oil. This suggests that raw sesame oil was more resistant to oxidation. The primary products of oxidation are not stable under heating and then they evolve to give secondary oxidation products that absorb at about 270 nm (Elleuch *et al.*, 2007). The generation of these secondary products has, as a consequence, a role in the break-up of the acyl group chains as suggested by Guillén and Ruiz (2004).

Figure 2 shows the change in absorptivity at 270 nm during accelerated conditions at 65°C. Absorptivity at 270 nm of raw sesame, sesame paste and olive oils did not considerably change during 45 days of accelerated storage. This also confirmed the resistance of raw sesame oil against oxidation. The higher oxidative stability of raw sesame oil could be attributed to the presence of such natural antioxidants as tocopherols, sesamin and sesamol (Elleuch *et al.*, 2007; Lee *et al.*, 2008; Shahidi *et al.*, 1997).

Figure 3 illustrates the change in peroxide

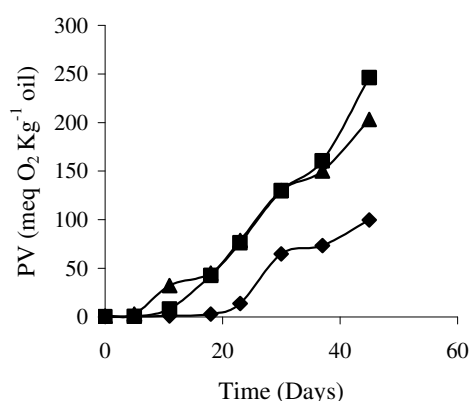


Figure 3. Change in peroxide value (meq O₂ kg⁻¹ oil) during storage period at 65°C of raw sesame, sesame paste and olive oils. (◆) Raw sesame oil; (▲) Sesame paste oil, (■) Olive oil.

value during heating at 65°C for 45 days. The peroxide values of raw sesame and sesame paste oils at 0 time of storage (fresh oil) were lower than those of olive oil (0.14 and 0.19 against 0.99 meq O₂ kg⁻¹ oil). The peroxide values obtained for raw sesame, sesame paste and olive oils occurred initially at a lower rate. Indeed, this period of time is called the Induction Period (IP) or Induction Time (IT) (Nissiotis and Tasiola-Margari, 2002). The induction periods are 23 days for raw sesame and 18 days for sesame and olive oils. In fact, the peroxide values reached approximately 13.83, 44.89 and 42.77 meq O₂ kg⁻¹ oil for raw sesame, sesame paste and olive oils, respectively. These results were similar to those reported by Elleuch *et al.* (2007).

With regard to olive oil stability, Nissiotis and Tasiola (2002) pointed out that the value of peroxide (20 meq O₂ kg⁻¹) is interesting because up to this value, the virgin olive oil is not characterized as “extra”. It is important to determine the antioxidant concentration during thermal oxidation at 65°C up to a peroxide value of 20 meq O₂ kg⁻¹.

The change in viscosity of raw sesame, sesame paste and olive oils stored at 65°C is presented in Figure 4. Raw sesame and sesame paste oils showed a lower viscosity

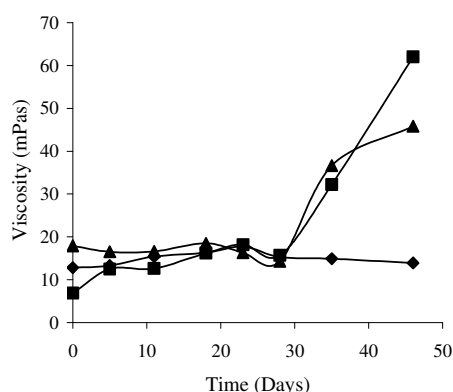


Figure 4. Change in viscosity during storage period at 65°C of raw sesame, sesame paste and olive oils. (◆) Raw sesame oil; (■) Sesame paste oil, (▲) Olive oil.

(between 12.8 and 32.2 mPa s) than most vegetable oils (Mean value \approx 50-100 mPa s) as reported by Besbes *et al.* (2005), but comparable to that of oleic acid and raspberry's cores studied by Oomah *et al.* (2002) (18 mPa s and 26 mPa s, respectively).

CONCLUSIONS

The results revealed that raw sesame seed is a rich source of many important nutrients that appear to have positive effects on human health. The characterization of raw sesame, sesame paste and olive oils suggested that these oils could be utilized as a potential source of edible oils for human consumption. The raw sesame, and sesame paste contained high monounsaturated to saturated fatty acid ratios, and might be desirable substitutes for highly monounsaturated oils such as olive oil in diets. Compared to sesame paste and olive oils, raw sesame oil presented a higher content in free fatty acids and more stability in the face of oxidative conditions.

All these characteristics lead to more diverse and novel applications of sesame oil as well as olive oil in food, cosmetics and pharmaceutical products.

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خصوصیات شیمیایی و پایداری نسبت به اکسید شدن روغنهای دانه و پوره کنجد و روغن زیتون

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چکیده

دانه کنجد دارای روغن، پروتئین و خاکستر زیاد است، نتایج نشان داد که دانه کنجد دارای درصد بالایی روغن، پروتئین و خاکستر است. مقدار آنها به ترتیب ۵۲، ۲۴ و ۵ درصد است. برخی از خصوصیات کیفی روغن کنجد و زیتون مورد مطالعه قرار گرفت. نتایج زیر به ترتیب حاصل این مطالعات برای روغن دانه و پوره کنجد و روغن زیتون است. مواد غیر قابل صابونی شدن ۱/۳۵، ۱/۴۶ و ۱/۵ درصد، فنولها، ۱۴/۲۱، ۱۶/۸۲ و ۵۳/۳۳ میلی گرم در کیلوگرم روغن؛ کلروفیل ۰/۰۹ و ۰/۰۴ و ۱/۸۸ میکروگرم در گرم؛ کاروتن ۲/۶۲، ۳/۶۶ و ۱۹/۱۰ میکروگرم بر گرم؛ اندیس انکساری (Refractive) ۱/۴۷، ۱/۴۷ و ۱/۴۷، عدد صابونی ۱۸۶/۶، ۱۸۵/۷۵ و ۹۷/۹۴؛ عدد یدی ۱۱۳/۳۵، ۹۱/۳۴ و ۸۱/۲۳ و اسیدیته ۱/۶۴، ۱/۱۰ و ۱/۱۲ میلی گرم پتاس (KOH) بر گرم روغن، پروفیل اسیدهای چرب روغن دانه کنجد، پوره کنجد و روغن زیتون نشان دهنده غالب بودن اسید اولئیک (به



ترتیب ۴۱/۶۸، ۴۱/۹۴ و ۵۲/۱۴ درصد) است. اسید چرب بعدی لینولئیک اسید (به ترتیب ۳۸/۲۹، ۳۷/۴۸ و ۱۷/۸۲ درصد) می‌باشد. اثر انبارداری دانه کنجد، پوره کنجد و روغن زیتون در دمای ۶۵°C ارزیابی شد. نتایج نشان داد که پایداری روغن دانه کنجد نسبت به اکسید شدن بیشتر از روغن پوره کنجد است. با توجه به خصوصیات خوب روغن کنجد می‌توان آنرا در محصولات غذایی و آرایشی استفاده کرد.