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Fatty Acids Composition and Oxidative Stability of Peanut and Sesame Oils with the Sensory Evaluation of Mayonnaise Prepared by Different Oils

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Abstract:

The purpose of this study was to increase the nutritional value and health benefits of mayonnaise made by using peanuts and sesame oils. In this study, samples of peanuts and sesame oils were analyzed to measure fatty acid compositions and to evaluate the effects of heating time at (180°C ± 5°C) up to 16 hours on the oxidative stability by UV-spectrum. The sensorial properties such as (general shape, smell, color, taste, texture, smoothness, overall acceptance) were studied for the mayonnaise made by different oils. Quantitatively, the percentage of fatty acids in peanuts and sesame oils were (9.94–12.11%) for palmitic acid, (32.88–47.60%) linoleic acid, (0.08–4.99%) linolenic acid, (3.97–5.77%) stearic acid, (30.60–41.07%) oleic acid, (ND–1.93%) arachidic acid, (0.09–0.22%) palmitoleic acid, (0.43–1.31%) gadoleic acid, (0.61–4.16%) behenic acid, (ND–1.95%) legnoceric acid, and (0.03–0.09%) for myristic acid. The UV spectrum at 200-400 nm showed obviously difference between peanut and sesame oils. The main difference of both oils spectrum was between 256 and 310 nm, while peanut oil had a small peak in this region (17 % of total peanut oil peaks area). The sesame oil had a high peak in such region (58 % of total sesame oil peaks area). According to the sensorial evaluation results, it could be demonstrated that mayonnaise made by using peanut oil was acceptable. These sensorial results could be considered in the manufacturing processes.

Keywords: *Mayonnaise, Fatty acids, Oxidative stability, Sensorial evaluation.*

Introduction:

Mayonnaise is one of the widespread appetizers demand in recent. It is an important source of protein, fat, fat soluble vitamins as it contains 70-80% vegetable oil (Savage and Depree, 2001). Mayonnaise is defined according to The Agency for Food and Drug Administration (FDA) as an emulsion food and is produced from plant edible oil, vinegar, lemon, egg yolks, salt, sugar, mustard and some natural spices. Vegetable oils used in mayonnaise usually are corn, sun flower, olive and soy bean is the cheapest. There are many studies of mayonnaise applications in food processes and medical treatments as (Rahmati *et al*., 2014; Rahbari *et al*., 2015; Shinn *et al*., 2016). Pro-oxidative effect of fresh and freeze-dried vegetables during storage and the anti-oxidative effect of purple corn extracts during storage of mayonnaise had been studied (Le *et al*., 2014; Raikos *et al*., 2015). Oils and fats are the essential materials for margarine, shortening, salad oil, and other specialty or tailored products, which have become significant ingredients in food preparation or processing in homes, restaurants, or food manufacturers. The majority of the edible oils and fats produced worldwide annually is derived from plant sources and is referred as vegetable oils (Lemuel and Tianying, 2014).

The cultivated peanut *(Arachis hypogaea L.)* is an important annual oilseed crop planted as a food group throughout the world (Jeffrey *et al*., 2013). Sesame oil is derived from the plant species (*Sesamum indicumL.)* a herbaceous annual belonging to the Pedaliaceae family. The main constituents of these oils include fatty acids, lignans, and antioxidants, such as tocopherol (Dur-Zong *et al*., 2013). Oils are rich source of unsaturated fatty acids. The use of natural components in reducing cardiovascular diseases and cancer mortality has gained considerable attention. Lipid components greatly contribute to the nutritional and sensory value of almost all types of foods. Nature provides a large number of fats that differ in their chemical and functional properties. Four classes of lipids are habitually found in vegetable oils: triacylglycerols, diacylglycerols, polar lipids, and free fatty acids. The fatty acid composition determines the physical properties, stability, and nutritional value of lipids. The most naturally occurring storage lipids are triacylglycerols. Triacylglycerols are natural compounds that consist of saturated and unsaturated fatty acids that differ in the length of their acyl chains and the number and positions of double bonds: saturated, monoenoic, and polyunsaturated fatty acids that differ with respect to detailed fatty acid composition. Monoenoic fatty acids and polyunsaturated fatty acids are structurally distinguished by the presence of repeating methylene units. These units produce an extremely flexible chain that rapidly reorients through conformational states and constitutes an influential group of molecules that promote health (Rokayya *et al*., 2013).

Oil oxidation is an autocatalytic reaction generating hydroperoxides from unsaturated acylglycerols. Oxidation of polyunsaturated food lipids often affect on development of unpleasant tastes and odors, characteristic of rancid fats and oils, as well as degradation of functional and nutritional properties. Lipid oxidation can directly reflect shelf life of a product. Environmental factors, such as air, light and temperature, accelerate oxidative reactions which might end in the production of off-flavors and odors associated with low molecular weight volatiles, discoloration (Navarro *et al*., 2012). Also, oxidation induces important chemical changes of the oils that may affect directly the quality of the edible oil, generates radical oxygen species that may cause irreversible damages when reacting with biological molecules such as DNA, proteins or lipids (Bansal *et al*., 2010; Cabiscol *et al*., 2010). Lipid oxidation has harmful effects on both food quality and human health. Efforts must be made to minimize oxidation and improve oxidative stability of lipid products. The kind of oils and their oxidative stability are very important indicators which can help to know how long oils can be used.

The aim of the present study was to investigate and compare fatty acids composition in peanut and sesame oils. The degradation of oxidized oils was also investigated. In addition, study the supplementation of different edible oils with mayonnaise and its relationship with the sensorial evaluation.

Materials and Methods:

Samples and reagents:

Different oils, egg, vinegar, salt, sugar, and mustard were provided from a local supermarket (Taif, Kingdom of Saudi Arabia). Xanthan, guar gum and fatty acid methyl ester (FAME) standards were purchased from Sigma (St. Louis, MO, USA). All solvents were of reagent grade and purchased from Sigma Chemical Co. (St Louis, MO, USA) and were used without any further purification.

Analysis of Fatty Acids Composition:

The fatty acids methyl esters (FAMEs) were prepared by the following two steps: (1) oils were saponified with 0.5 M KOH; (2) later methylated with 40% BF_3 in methanol (Li *et al*., 2012). Gas chromatography mass spectrometry (GC/MS) analysis was carried out with an Agilent 6890- 5973 (Agilent Technologies, CA, USA) instrument. Separating procedure was achieved on an Agilent HP-88 capillary column (100×0.25 mm i.d., film thickness 0.2 μm). The operating conditions were as follows: carrier gas pressure, 100 kPa; carrier gas, helium; split ratio was 1:30; injection temperature, 250°C; scanning scope: 50- 550 amu; ionization voltage: 70 eV. Oven temperature was programmed as follows: held at 80°C for 5 min, and then rising to 150°C at 10°C /min, and held for 2 min at 150°C; then continuously rising to 230°C at 5°C /min and held for 10 min. The individual fatty acids were identified and quantified by comparing their retention times with external standards.

Oxidative Stability Assay:

Approximately 250 ml of oil were placed in glass beaker and subjected to heating on an electric hotplate device, stirring manually with a glass rod. The temperature was measured using a thermometer to keep temperature within (180° ± 5°C) level. Samples took every two hours up to the end of heating period after 16 hours. 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 measured at 221 nm for hydroxynonenal, 245 nm for malonaldehyde, at 290 nm for acetaldehyde and 268-270 nm for conjugated triene formations, respectively by (Shimadzu UV-1601 PC, UV-Visible, China) spectrophotometer (Bohnstedt, 2005).

Sensorial Evaluation:

Mayonnaise model emulsions were prepared as samples of high oil emulsions with different oils (sun flower, peanut, soy, olive, camellia, sesame and rice bran). Mayonnaise ingredients were oil 68 %, egg yolk 10 %, vinegar 7.9 %, xanthan 0.15 %, guar 0.15 %, water 10 %, sugar 3 %, salt 0.5 % and mustard 0.3 % (Kobra *et al*., 2014). To prepare different mayonnaises types; first, powder ingredients (salt, sugar, xanthan, guar, and mustard), water, and egg yolk were mixed with stirrer for 4 min at 800 rpm. Then 1/3 of vinegar was added and mixed for 2 min with the same speed. Then different oils were added slowly in 8 min at 1,100 rpm into aqueous phase. The rest of the vinegar was poured (2/3 of vinegar) and mixed for 2 other minutes. Then this pre–emulsion was homogenized with the stirrer operating at 1,500 rpm for 7 min.

Sensorial evaluation of the mayonnaise samples was took place in the community Department of Nutrition and Food Science, Taif University by 50 panelists. The panelists completed their evaluations during their scheduled appointment times between 10:00 am and 12:00 am (Sharareh *et al*., 2015). The researcher collected the signed consent forms. Participants were informed that the mayonnaise contained control (sun flower oil), peanut, soy, olive, camellia, sesame and rice bran oils, respectively. Panelists were asked not to communicate with each other until the evaluation was complete. Each participant was given seven samples of mayonnaise in random order, a pen, and a cup of water, which they were instructed to rinse their mouth between each tasting. Mayonnaise samples were placed in uniform plastic cups and served with a separate plastic spoon to ensure no carryover of sensory properties. Panelists were given uniform amounts of each sample approximately 45 ml and were asked to evaluate (general shape, smell, color, taste, textures, smoothness, overall acceptability) of each sample for general shape (25 points), smell (10 points), color (10 points), taste (10 points), textures (10 points), smoothness (10 points), overall (25 points) and Total scores (100).

Statistical Analysis:

Data from the replications of all samples were subjected to a variance analysis (ANOVA) using SPSS 16.0 for Windows. Significant differences between the means were determined by Duncan's new multiple range test ($P < 0.05$). The correlation between the sensorial evaluations of the different edible oils mayonnaise was determined by the principal component analysis (PCA) using XLSTAT software.

Results and Discussion:

Fatty Acids Analysis Composition

The fatty acids composition of peanut and sesame oils is presented in (Table 1). An examination of FAME derivatives showed twelve fatty acids. The total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) showed significant variation in their contents. Linoleic acid (32.88–47.60%) was the major fatty acid; linoleic acid is a doubly unsaturated fatty acid, occurring widely in plant glycosides. It is an essential fatty acid in mammalian nutrition and is used in the biosynthesis of prostaglandins and cell membranes (Ildiko *et al*., 2015). The next most common fatty acid was oleic acid (30.60–41.07%), which was most abundant in peanut oil, followed by palmitic acid (9.94–12.11%), stearic acid (3.97–5.77%) behenic acid (0.61–4.16%), gadoleic acid (0.43–

1.31%), linolenic acid (0.08–4.99%), palmitoleic acid (0.09–0.22%), legnoceric acid (ND–1.95%), arachidic acid (ND–1.93%) and myristic acid (0.03–0.09%). Similar fatty acid profiles for these oils have been also shown in several studies (Reena and Lokesh, 2007; Sharif *et al*., 2009). The present study proved that peanut and sesame oils are sources of beneficial fatty acids such as the polyunsaturated fatty acids. It has become increasingly popular in the cosmetics industry because of its beneficial properties on the skin, including anti-inflammatory, acne-reduluction, and moisture-retention properties (Darmstadt *et al*., 2002).

Table 1. Fatty acids composition of peanut and sesame oils

Fatty acid	Sesame Oil	Peanut Oil
Myristic acid (C14:0)	0.09±0.02c	0.03±0.01a
Palmitic acid (C16:0)	9.94±0.13a	12.11±0.10c
Palmitoleic acid (C16:1)	0.22±0.03c	0.09±0.01a
Stearic acid (C18:0)	5.77±0.05e	3.97±0.11d
Oleic acid (C18:1)	30.60±0.24b	41.07±0.57d
Linoleic acid (C18:2)	47.60±0.38d	32.88±0.35b
Linolenic acid (C18:3)	4.99±0.11e	0.08±0.01a
Arachidic acid (C20:0)	0.30±0.01a	1.93±0.04c
Gadoleic acid (C20:1)	0.43±0.03b	1.31±0.04d
Arachidic acid (C20:2)	N.D.	0.03±0.01a
Behenic acid (C22:0)	0.61±0.02b	4.16±0.09e
Lignoceric acid (C24:0)	N.D.	1.95±0.04a
Total SFA	16.71±0.12a	24.41±0.06f
Total MUFA	31.25±0.33b	42.49±0.25d
Total PUFA	52.59±0.47d	33.12±0.12b

Estimation of Oxidative Stability Results

Figs. (1-5) show the effect of heating time on hydroxynonenal (at 221 nm), conjugated diene (at 232-234 nm), malonaldehyde (at 245 nm), conjugated triene (at 268-270 nm) and acetaldehyde (at 290 nm) formation in peanut and sesame oils. The data revealed that all hydroxynonenal, conjugated diene, malonaldehyde, conjugated triene, and acetaldehyde steady increased during heating time up to 16 hours at 180°C ± 5°C.

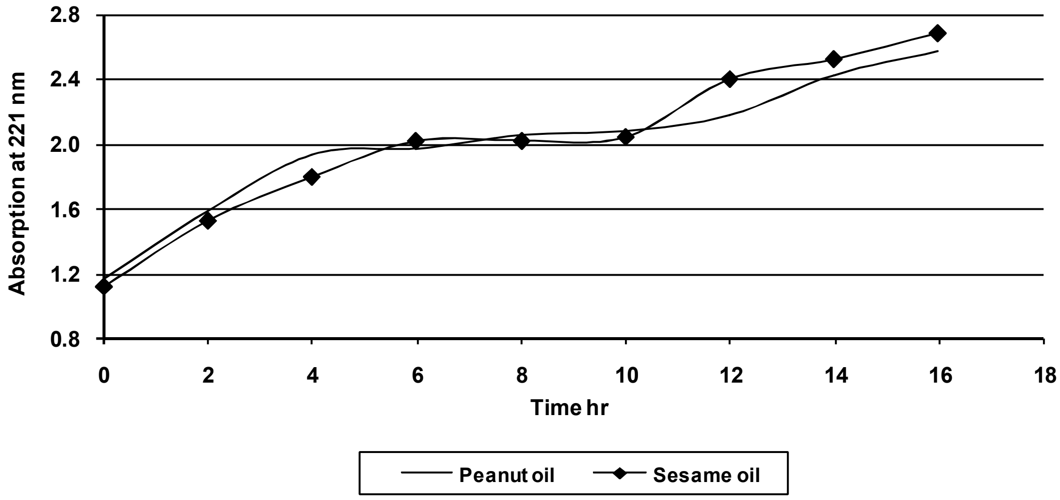

Fig. 1. Effect of heating time on hydroxynonenal formation

The initial value of hydroxynonenal at 221 nm of peanut and sesame oils was 1.17 and 1.11 increased to 1.97 and 2.02, respectively, after 6 hours of heating at 180°C ± 5°C, this value approximately stable or slightly increased during next four hours of heating time, then elevated gradually to reach 2.57 and 2.68 after 16 hours of heating for peanut and sesame oils, respectively (Fig. 1). From literature, most researchers measured both conjugated diene and triene in different crude or refined edible oils, but they focused only on measurement of alterations during heating, frying or storing of different edible oils on conjugated diene at 232-234 nm, that could be due to the alterations on this UV region which is very clear and not overlapping with other cromophore groups of UV spectrum.

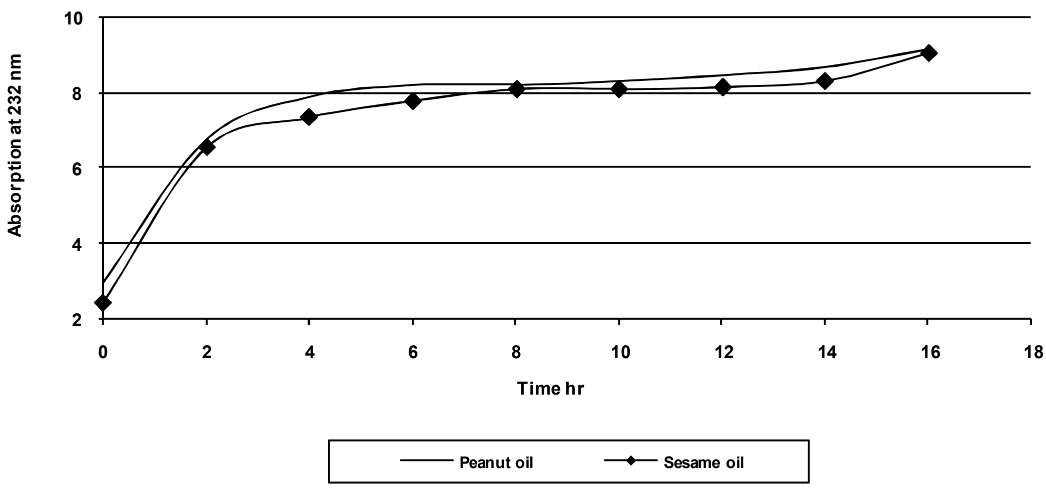

Fig. 2. Effect of heating time on conjugated diene formation.

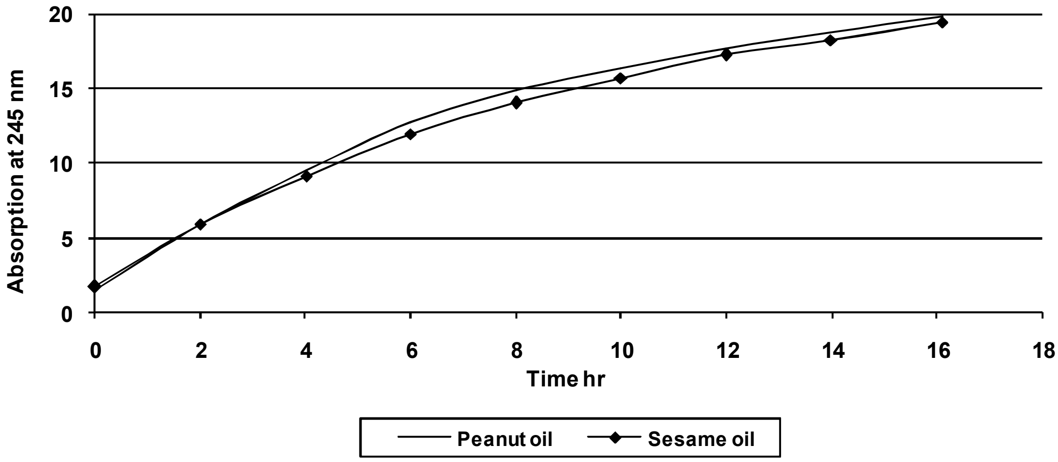

Fig. 3. Effect of heating time on conjugated triene formation

The same trend was noticed for conjugated diene at 232-234 nm but it shows sharp increment during first 2 hours of heating at 180°C ± 5°C, (from 2.96 and 2.41 to 6.77 and 6.55) for peanut and sesame oils, respectively, then continued gradually increased to 9.18 and 9.08 at the end of heating time after 16 hours, for peanut and sesame oils, respectively (Figs. 2, 3). According to Bird and Draper (1984), malonaldehyde formation determined by measured absorption at 245 nm. (Fig. 4) shows the effect of heating time on malonaldehyde formation of peanut and sesame oils. It reached to the highest after 16 hour as 19.50 and 19.88, for peanut and sesame oils, respectively. The values of absorption at 245 nm could be due to the formation of other secondary oxidation products produced by decomposition of peroxides or hydroperoxides formed in oil oxidation process, therefore this UV region may be helpful for lipid oxidation monitoring.

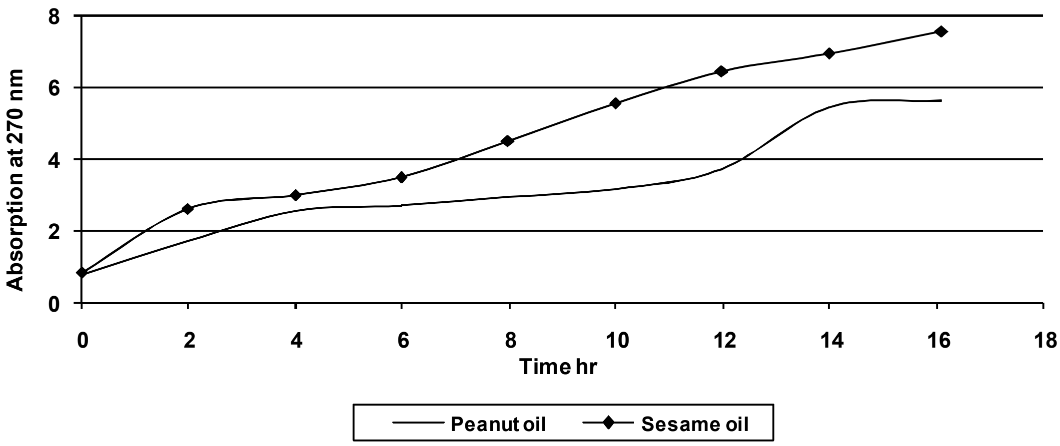

Fig. 4. Effect of heating time on malonaldehyde formation

(Fig. 5) shows the effect of heating time on acetaldehyde formation of peanut and sesame oils. The acetaldehyde value increased slightly within first four hours of heating period, afterward gradually increased up to 12 hours of heating at 180°C ± 5°C, followed by sharp increment due to peroxides and hydroperoxides decompose into secondary oxidation products mainly aldehydes. The initial value of acetaldehyde in sesame oil was higher than such value in peanut oil, that could be due to overlapping between acetaldehyde cromophore group and phenolic compound cromophore groups.

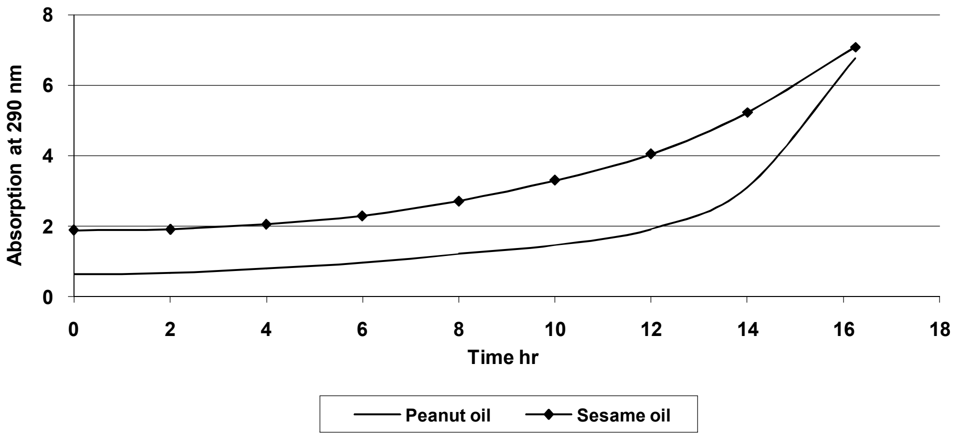

Fig. 5. Effect of heating time on acetaldehyde formation

Sensory Evaluation of Mayonnaise

The sensory properties of mayonnaise made by different oils such as general shape, smell, color, taste, texture, smoothness and overall acceptance are shown in (Table 2). Control sample showed the least acceptance value in comparison with the other samples may be due to the boredom of the usual form of mayonnaise. In the case of using sesame and olive oils in mayonnaise showed lower score when focusing on the general shape, respectively. The taste of mayonnaise made by sesame oil gave lower score than the other samples. According to total overall acceptability scores, it can be concluded that using peanut oil in mayonnaise was the most acceptable.

Table 2. Sensorial evaluation of mayonnaise types

	Control	Peanut	Soy	Olive	Camellia	Sesame	Rice bran
General shape	24.36±1.50a	24.18±2.62ab	23.82±2.88ab	22.72±5.10b	24.04±2.72ab	22.92±4.19ab	23.96±3.14ab
Smell	9.54±1.03ab	9.52±1.11ab	9.32±1.17ab	9.46±1.22ab	9.62±0.81a	9.10±1.52b	9.50±1.02ab
Taste	9.16±1.80a	9.28±1.81a	9.44±1.64a	8.90±2.27a	9.32±1.70a	8.84±2.28a	9.14±1.81a
Color	9.48±1.20a	9.56±0.86a	9.20±1.40ab	9.12±1.80ab	9.46±1.16a	8.80±2.17b	9.60±0.86a
Texture	9.72±0.78a	9.78±0.65a	9.60±1.09a	9.66±0.75a	9.48±1.20a	9.44±1.64a	9.74±0.69a
Smoothness	9.84±0.62ab	9.92±0.27a	9.58±0.95ab	9.42±1.30b	9.62±1.03ab	9.70±1.45ab	9.78±0.68ab
Overall acceptance	20.14±1.73b	24.04±2.69a	23.62±2.92a	23.52±2.88a	23.96±2.55a	23.28±3.52a	23.84±2.81a

(Figs. 6 and 7) present the plots of the scores and the correlation loadings of the PCA, respectively. The scores plot of PCA illustrates the large variability of the seven different oils on the basis of their sensorial evaluation in mayonnaise. The loadings are the coefficients of the original variables that define each principal component. Inertia percentage and correlated variables for axes 1 and 2 are displayed in (Table 3). Axes 1 explained 54.67% of the total inertia. Axes 2 explained 17.96% of the inertia and was made positive by overall, taste, general shape and color. The inertia was made negatively by smoothness. Plots of the scores in (Fig. 6) indicates that the data cloud was mainly bidimensional. With respect to the explanatory variables, (Fig. 7) shows three clusters of oils. The first cluster included the camellia, rice bran and peanut oils. The second cluster included the olive and soy oils. The third cluster (control and sesame oils) were individualized.

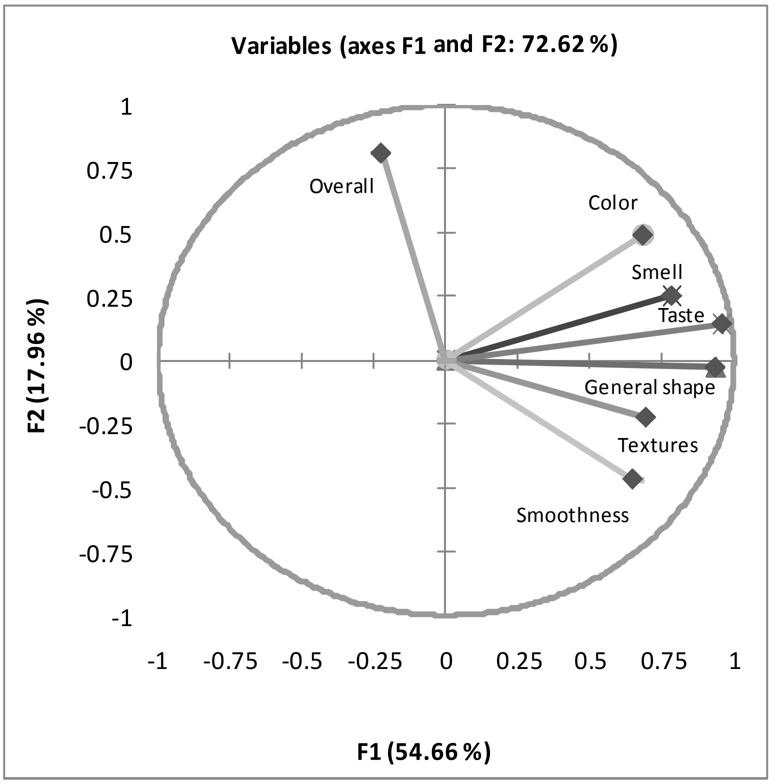

Fig. 6. Plots of the sensory evaluation scores

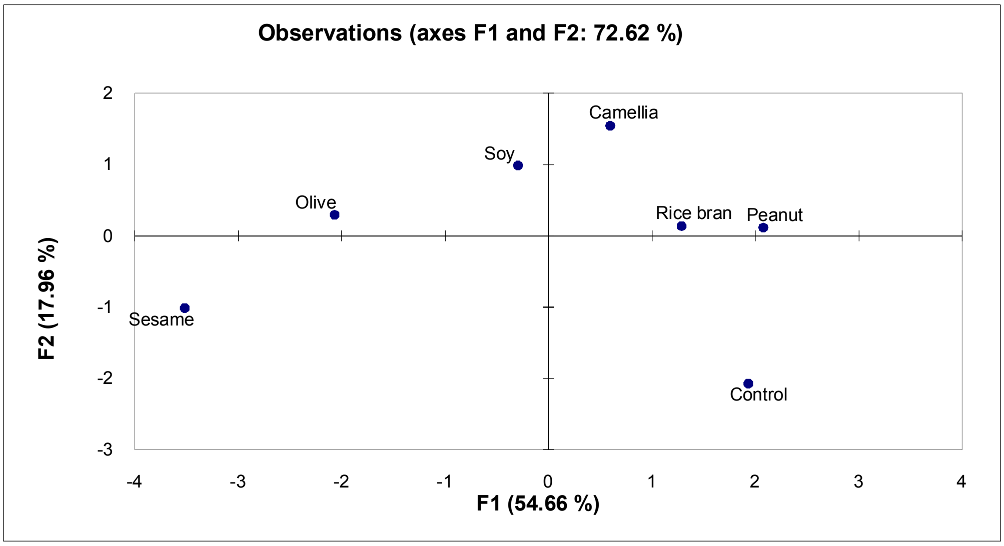

Fig. 7. Plots of the x-loudings

Table 3. Discriminate variables factors of principal components analysis of the sensory evaluation

	F1	F2
Proper value	3.83	1.26
Variability (%)	54.67	17.96
Cumulative (%)	54.67	72.62
General shape	+22.84	+0.06
Smell	+16.05	+5.08
Taste	+24.02	+1.62
Color	+12.19	+19.17
Texture	+12.57	-4.01
Smoothness	+10.99	-17.41
Overall	-1.35	+52.65

Conclution:

Based on our data, the fatty acid results were in agreement with the literature. Sesame oil proved higher inhibition on the oxidation stability than peanut oil. In the case of the sensorial evaluation, using peanut oil in mayonnaise was acceptable.

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تركيب الاحماض الدهنية والثبات التاكسدى لزيوت السمسم والفول السودانى مع دراسة التقييم الحسى للمايونيز المحضر بانواع مختلفة من الزيوت

ابتهال يعقوب خوجه ، رقية احمد سامى الديب

قسم التغذية وعلوم الاطعمة كلية التصاميم والاقتصاد المنزلي جامعة الطائف المملكة العربية السعودية

الملخص:

يهدف هذا البحث إلى زيادة القيمة الغذائية للمايونيز باستخدام زيت السمسم وزيت الفول السوداني. وقد تمت دراسة تركيب الاحماض الدهنية وكذلك التغيرات التي تحدث أثناء المعاملة الحرارية لهذه الزيوت على درجة حرارة (١٨٠± ٥) درجة مئوية لمدة ١٦ ساعة باستخدام الطرق الطيفية (الأشعة فوق البنفسجية). إلى جانب دراسة الخصائص الحسية مثل (الشكل العام، الرائحة، اللون، الطعم، القوام، النعومة والقبول العام) للمايونيز المحضر باستخدام انواع مختلفة من الزيوت.

ويمكن تلخيص النتائج المتحصل عليها كالتالي:

- كميا، كانت نسب الأحماض الدهنية في زيت السمسم وزيت الفول السوداني تتراوح بين (٩,٩٤ –١٢,١١٪) لحمض البالمتيك، (٣٢,٨٨ –٤٧,٦٠٪) حمض اللينوليك، (٠,٠٨–٤,٩٩٪) حمض اللينولينيك، (٣,٩٧ –٥,٧٧ ٪) حامض السياتريك، (٣٠,٦٠ –٤١,٠٧ ٪) حمض الأوليك، (ND-1.93٪) حمض الأراكيديك، (٠,٠٩–٢٢,٠٪) حمض البالمتيوليك، (٠,٤٣ – ١,٣١ ٪) حمض الغادولييك، (٠,٦١ -٤,١٦٪) حمض بيهينيك، (ND-1.95٪) حمض ليغنوسيريك، و(٠,٠٣ –٠,٠٩ ٪) للحمض الميريستيك.
- أظهر طيف الأشعة فوق البنفسجية بوضوح الفرق بين زيت السمسم وزيت الفول السوداني وكان الفرق الأساسي في نطاق الاطوال الموجية ٢٥٦–٣١٠ نانوميتر، في حين أظهر زيت الفول السوداني منحنى صغير في هذه المنطقة (١٧٪ من إجمالي منحنى زيت الفول السوداني)، فقد اظهر زيت السمسم منحنى عالي في هذه المنطقة (٥٨٪ من إجمالي منحنى زيت السمسم).
- وفقا لنتائج الاختبارات الحسية، فان المايونيز المصنع باستخدام زيت الفول السوداني كان أكثر قبولاً. ويمكن الأخذ في الاعتبار بهذه النتائج الحسية في تصنيع منتجات غذائية عالية القيمة الغذائية.