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Antioxidant activity of sesame oil on oxidative stability of olive oil

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In this study, the effects of blending sesame oil with olive oil at different concentrations (5%, 15% and 25%) and storing the oil blend at 60°C for 30 days in relation to the physicochemical properties and fatty acid composition were determined. Peroxide value, free fatty acid, *p*-anisidine, K_{232} and K_{270} values were analyzed on the 15th and 30th days in olive oil as well as sesame/olive oil blend. After 15 days of storage, the lowest peroxide value (3.73 meq O_2/kg) was obtained in olive oil containing 5% sesame oil, while olive oil containing 25% sesame oil has lowest peroxide value of 4.95 meq O_2/kg after 30 days of storage. The lowest free fatty acid values were found in olive oils, with the values of 1.45% for 15th day and 1.67% for 30th day. The result revealed that peroxide and *p*-anisidine values increased, while the free fatty acid and ultraviolet absorption at 232 and 270 nm decreased during storage at 60°C. Minimum free fatty acid (1.45%) was found in olive oil stored for 15 days, while the K values were in the range (0.01-0.02) following analysis on 30th day. This study revealed that addition of sesame oil to olive oil improved the antioxidative property of oil blends.

Keywords: Fatty acids, Olive oil, Oxidative stability, *p*-anisidine, Sesame oil

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Sesame (*Sesamum indicum* L.) is one of the oldest oil plants being cultivated for around 4000 years and the current global production stands at 6.1 million tons[1,2]. About 54% of total world production originates from Africa (majorly from Tanzania, Sudan and Nigeria), 43% from Asia (majorly from Myanmar, India and China) and the remaining 3% from America and Europe[1]. Blending of vegetable oil has emerged as an economical way of modifying the physicochemical characteristics of vegetable oils besides enhancement in oxidative stability[2]. The recent increment of sesame seeds cultivation can be attributed to its wide applications in industries particularly in the production of healthy and nutritious products. Apart from being an important oil seed, it has significant amount of natural antioxidants, which makes it suitable for use in pharmaceutical and cosmetic industries. Sesame oil is more stable and resistant to oxidative deterioration than other vegetable oils and it can remain intact for relatively longer periods of time[3-5]. The natural antioxidants including sesamin, sesamol and sesamolin contribute to the stability of sesame oil[6]. Sesamol is a nontoxic antioxidant for edible oils because it is resistant to high cooking temperatures[7]. Nutritionally, sesame oil is a very rich source of polyunsaturated fatty acids such as linoleic acid and oleic that makes it a perfect raw material for production of margarine and cooking oil. Intake of diet rich in oleic acid has been linked to various health promoting benefits such as decreased blood pressure[8], prevention of ulcerative colitis[9] and protection against free radical damage[10]. Sesame oil is of high quality and has preservative like attributes due to the presence of a natural preservatives within the oil called sesamol[3,11,12]. Oil stability during storage is an important measure for ensuring good oils and oxidation is known to be the major problem affecting edible oils. During refining, majority of natural antioxidants in oils are removed[13], which often necessitate the need to add antioxidant after processing to retard oxidation[14]. Synthetic antioxidants are known to have various adverse effects on the body, hence, there is need to identify natural antioxidant that would serve the same purpose as synthetic ones. Mixing of vegetable oils could serve as prudential and economical approached to produce natural edible oils that have undergone least chemical treatments and carrying natural flavor and nutritional importance. Olive tree (*Olea europeae* L.) is nativeto Anatolia, and its fruit and seed oil are in

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dispensable foods in breakfasts and preparation of different dishes and salads. The production of nutritious olives that contribute to human health improvement is concentrated in the Aegean and Eastern Mediterranean region[15]. Natural olive oil is oil extracted from the fruits of the olive tree by mechanical or physical methods. The most important characteristic of olive oil is its distinctive taste, presence of phenolic compounds and antioxidant properties and all these have positive effects on health. In addition, it is known that there is a linear relationship between oxidative resistance and phenolic content of extra virgin olive oil[15]. The current study was therefore carried out to determine the effect of incorporating sesame oil to olive oil at different concentrations (5%, 15% and 25%) and storage at 60°C for 30 days on oxidation stability and fatty acid composition of olive oil.

Material and Methods

Material

Extra virgin olive and sesame oils were purchased from a local market in Konya. All chemical used were of analytical grade and procured from Sigma-Aldrich (Sigma Chemical Co., St. Louis, MO, USA).

Methods

The 25 mL samples from the olive oil sample were taken into glass bottles. The control sample was separated and 5%, 15%, 25% of sesame oil was added to each olive oil and stored in amber bottle at without light conditions at 60°C for 0, 15, 30 days.

Determination of fatty acid composition

The method described by ISO-5509[16] using n-hexane and methanolic KOH was used for esterification of oliveoil samples. Analysis of fatty acid esters was done using gas chromatography (Shimadzu GC 2010). In the process, flame ionization detector (FID) and capillary column (Technochroma TR CN100, P/N TR 882162 fused silica column, 60 m x 0.25 mm x 0.20 µm) were used. The detector and in jection block temperatures are 260°C. Nitrogengas is used as mobile phase and the flow rate is 1.51 mL / min. Flow rate of 80 mL/min and the splitratio is 1/40 mL / min was used and temperature program; keep at 7°C for 90°C, increaseto 5°C / min to 240°C, wait for 15 min at this temperature.

Free fatty acid

The method described by AOCS[17] was employed in free fatty acid contents determination. In the process, the oil samples were dissolved in ethanol / diethylether (1:2 v/v) solution and titrated with 0.1 N KOH solution.

Peroxide value

Addition of chloroform / aceticacid (50:50 mL) to olive oil samples was determined in meq O_2/kg by titration of freeiodine released by reaction with potassium iodide solution in the dark against sodium thiosulfate solution[17].

Determination of *p*-anisidine

Olive oil sample (0.5 g) was weighed and 50 mL of isooctane added. Also device was reset with isooctane. After 5 mL oil solution was taken, 1 mL of *p*-anisidine solution is addedto it. After about 5 mL solvent (isooctane) was taken into another tube, 1 mL *p*-anisidine solution was added and kept for 10 min. The device was reset with a solution of 5 mL solvent and 1 mL of *p*-anisidine. Measurement of prepared tubes was done, respectively and Ab, As values were recorded[17].

Specific absorption values (K232, K270, ΔE)

After 0.5 g olive oil was weighed, 50 mL of cyclohexane was added to it. About 2 mL sample was taken into 1cm quartz and measured quickly at 232 nm and 270 nm[17].

Statistical analysis

A complete randomized split plot block design was used for the research data and analysis of variance (ANOVA) was performed by using JMP version 9.0 (SAS Inst. Inc., Cary, N.C.U.S.A). All analyses were carried out in triplicates and the results are mean ± standard deviation (MSTAT C) of 25 independent sesame and olive oil samples and concentrations[18].

Results

The peroxide values, free fatty acids, *p*-anisidine, K_{232} and K_{270} values of the oil samples are given in Table 1. The initial peroxide values changed between 1.98 meq O_2/kg and 2.46 meq O_2/kg. However, the peroxide values increased with storage in an oven at 60°C. After 15 days of storage, the lowest peroxide value (3.73 meq O_2/kg) was determined in olive oil containing 5% sesame oil, while olive oil containing 25% sesame oil has lowest peroxide value of 4.95 meq O_2/kg after 30 days of storage. The lowest free fatty acid values were found in olive oils, with the values of 1.45% for 15th day and 1.67% for 30th day. Accordingly, the addition of sesame oil partially

Table 1 — The chemical properties of olive oil containing 0, 5, 15 and 25% sesame oil (SO: sesame oil; OO: olive oil)

0^{th} day	Peroxide value (meq O_2/kg)			Free fatty acid (%)			*p*-Anisidine			K_{232}			K_{270}		
OO	2.46	±	0.01*a	2.52	±	0.15a	6.64	±	0.79c	0.65	±	0.01b	0.06	±	0.00d
5% SO	2.22	±	0.35c**	2.51	±	0.08b	7.07	±	2.30b	0.69	±	0.01a	0.08	±	0.01c
15% SO	1.98	±	0.00b	2.50	±	0.08b	6.41	±	0.34d	0.53	±	0.00d	0.12	±	0.00b
25 % SO	2.22	±	0.33b	2.22	±	0.14c	7.97	±	2.32a	0.64	±	0.01c	0.14	±	0.00a
15^{th} day															
OO	4.40	±	0.08c	1.45	±	0.00c	6.62	±	0.79c	0.64	±	0.01b	0.06	±	0.00cd
5% SO	3.73	±	0.33d	1.46	±	0.00c	7.13	±	2.32b	0.69	±	0.01a	0.08	±	0.01c
15% SO	4.68	±	0.25a	1.56	±	0.00b	6.25	±	0.53d	0.54	±	0.00c	0.12	±	0.00b
25 % SO	4.48	±	0.74b	1.80	±	0.00a	7.91	±	2.30a	0.64	±	0.01b	0.14	±	0.00a
30^{th} day															
OO	6.96	±	0.82a	1.67	±	0.00d	8.15	±	0.13b	0.01	±	0.00	0.02	±	0.00a
5% SO	5.94	±	0.05b	1.75	±	0.00c	10.64	±	0.55a	0.01	±	0.00	0.02	±	0.00a
15% SO	6.18	±	0.32b	1.86	±	0.08b	8.48	±	0.21b	0.01	±	0.00	0.01	±	0.00b
25% SO	4.95	±	0.83c	1.97	±	0.00a	10.40	±	0.63a	0.00	±	0.00	0.02	±	0.00a

* The data show mean (n = 3) ± standard deviation.
** The different letters in the same column show statistically significant differences according to the Tukey test ($p<0.01$).

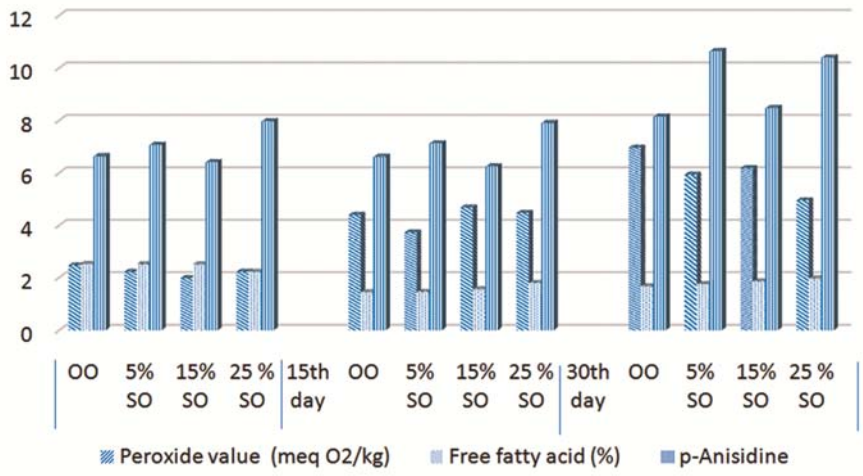

Fig. 1 — The chemical properties of olive oil containing 5, 15 and 25% sesame oil (SO: sesame oil; OO: olive oil)

affected the free fatty acid content of olive oil. While the initial *p*-anisidine, K_{232} and K_{270} values ranged between 6.41-7.97, 0.53-0.69 and 0.06-0.14, respectively and also close to the results of 15th day, the *p*-anisidine values increased after storage for 30 days while K_{232} and K_{270} values decreased (Fig. 1).

The fatty acid compositions of oil samples are presented in Table 2. The main fatty acids of olive oil was oleic (73.54%), palmitic (11.44%) and linoleic (8.99%). It was observed that the oleic and palmitic acid contents of olive oil reduced and the linoleic acid content increased following addition of sesame oil to olive oil. After 15 days, the oleic acid content of olive oil containing 5%, 15% and 25% sesame oil further reduced to 60.70%, 60.75% and 46.94%, while the linoleic acid contents increased to 23.47%, 23.42% and 39.88%, respectively.

Discussion

Allouche *et al.*[19] reported that the peroxide, K_{232} and K_{270} values of unheated virgin olive oil belonging to Arbequina and Picual cultivars were 10.10 and

Table 2 — The fatty acid compositions (%) of olive oil containing 5, 15 and 25% sesame oil (SO: sesame oil; OO: olive oil)

0th day	OO	5% SO	15% SO	25% SO
Palmitic	11.44± 0.55a	11.47± 0.68a	10.72± 0.35b	10.17± 0.14b
Stearic	2.72± 0.03c	2.83± 0.04b	2.82± 0.04b	2.97± 0.01a
Oleic	73.54± 0.54a	71.74± 0.59b	69.03± 0.21c	65.65± 0.18d
Linoleic	8.99± 0.08d	10.68± 0.09c	14.22± 0.00b	18.05± 0.09a
Arachidic	0.43± 0.01a	0.41± 0.01b	0.40± 0.03bc	0.41± 0.03b
Linolenic	0.50± 0.00c	0.51± 0.00b	0.50± 0.00c	0.53± 0.00a
Behenic	0.11± 0.01d	0.13± 0.01c	0.16± 0.02b	0.21± 0.02a
Arachidonic	0.52± 0.07a	0.51± 0.07b	0.45± 0.07d	0.46± 0.08c
15th day				
Palmitic	12.16± 0.12a	9.92± 0.73b	9.92± 0.73b	7.42± 0.44c
Stearic	2.66± 0.02c	2.99± 0.05b	2.99± 0.05b	3.20± 0.02
Oleic	72.41± 0.23a	60.70± 0.51b	60.75± 0.51b	46.94± 0.30c
Linoleic	9.61± 0.04c	23.47± 0.12b	23.42± 0.12b	39.88± 0.19a
Arachidic	0.40± 0.01a	0.37± 0.02b	0.37± 0.02b	0.34± 0.00c
Linolenic	0.35± 0.24b	0.53± 0.00a	0.53± 0.00a	0.53± 0.00a
Behenic	0.11± 0.01c	0.25± 0.00b	0.25± 0.00b	0.42± 0.03a
Arachidonic	0.54± 0.02a	0.37± 0.01b	0.37± 0.01b	0.22± 0.03c
30 th day				
Palmitic	12.08± 0.17a	11.13± 0.98b	11.43± 0.45b	10.88± 0.33c
Stearic	2.69± 0.00c	2.86± 0.12a	2.75± 0.02b	2.86± 0.02a
Oleic	73.11± 0.16a	66.07± 8.04c	69.21± 0.31b	66.69± 0.23c
Linoleic	8.75± 0.05c	16.85± 9.17a	13.40± 0.08b	16.46± 0.06a
Arachidic	0.41± 0.01a	0.38± 0.03c	0.39± 0.01b	0.39± 0.00b
linolenic	0.46± 0.00d	0.51± 0.03a	0.47± 0.00c	0.49± 0.00b
Behenic	0.12± 0.00c	0.19± 0.08a	0.17± 0.01b	0.19± 0.01a
Arachidonic	0.62± 0.04a	0.45± 0.17d	0.56± 0.02b	0.52± 0.02c

* The data show mean (n = 3) ± standard deviation.
** The different letters in the same column show statistically significant differences according to the Tukey test ($p<0.01$).

10.74 meq O_2/kg; 1.96 and 1.67; 0.09 and 0.12, respectively. In the study reported by Allouche *et al.*,[19], the initial oleic, linoleic and palmitic acid contents were 64.73%, 12.80% and 14.34% for Arbequina; 77.04%, 4.90% and 10.63% for Picual. The oleic and palmitic acid contents of olive oils increased to 67.72% from 16.65% for Arbequina; 78.06% from 12.15% for Picual, while the linoleic acid content of Arbequina and Picual oils decreased to 9.44% and 2.64%, respectively during thermal process at 180°C for 36h. According to Hemalatha-Ghafoorunissa[14], addition of sesame oil to preferred oil might increase the antioxidant activity and sesame lignans can be more effective than synthetic antioxidants. In previous study, blends (10% and 20%, w/w) of cold pressed oils including black cumin oil, cumin oil, coriander oil and clove oil with high linoleic sunflower oil were formulated and oxidative stability and radical scavenging activity of sunflower oil and blends stored under oxidative conditions (60 C) for 8 days were studied[20]. By increasing the proportion of black cumin oil and coriander oil in sunflower, linoleic acid level decreased, while tocols level increased and progression of oxidation was followed by measuring peroxide value, *p*-anisidine value, conjugated dienes and conjugated trienes[2]. According to results, inverse relationships were noted between peroxide value as well as anisidine value and oxidative stability at termination of storage[20]. Blends (10% and 20%, w/w) of black cumin seed oil and coriander seed oil with corn oil were formulated. Oxidative stability and radical scavenging activity of corn oil and blends stored under oxidative conditions (60°C) for 15 days were studied. By increasing the proportion of black cumin seed oil and coriander seed oil in corn oil, levels of polyunsaturated fatty acids decreased, while monounsaturated fatty acids content increased[21]. Blends (10 and 20%, w/w) of black

cumin oil and coriander oil with sunflower oil were formulated. Oxidative stability and radical-scavenging activity of sunflower oil and blends stored under oxidative conditions (60°C) for 15 days were studied[2]. By increasing the proportion of black cumin oil and coriander oil coriander oil in sunflower oil, linoleic acid content decreased, while oleic acid content increased. Progression of oxidation was followed by measuring peroxide value, conjugated dienes and conjugated trienes. Inverse relationships were noted between peroxide values and Oxidative stability at termination of storage[2]. Levels of conjugated dienes and conjugated trienes in sunflower oil and blends increased with an increase in time. sunflower oil: black cumin oil and sunflower oil: coriander oil blends gave 8-18 and 22-32% inhibition of DPPH radicals, respectively[2]. Free fatty acid content of the freshly prepared oil samples varied between 2.50% and 2.52%. Contrary to peroxide values, a reduction was observed in free fatty acid results with heat treatment at 60°C for both 15 days and 30 days (Fig. 1). The heat treatment of olive oil and corresponding blends at 180°C caused a major increase in peroxide and K values due to formation of conjugated dienes or peroxides and trienes or unsaturated aldehydes and ketones. The fatty acid compositions, especially oleic and linoleic acid contents, of olive oils changed according to the amount of sesame oil. Similarly, after 30 days of storage, a decrease in oleic acid and an increase in linoleic acid were observed in the oil blends. However, the rate of decrease or increase for 30th day was lower than 15th day.

Conclusions

The need to replace synthetic food additives with natural ones is on the rise in recent times because of their perceived health benefits. Sesame oil is highly stable to oxidative deterioration due to the presence of natural antioxidants such as sesamin, sesamol and sesamolin in its oil. This study revealed that addition of sesame oil to olive oil improved the antioxidative property of oil blends.

Conflict of Interest

The authors declare that they have no conflict of interest.

Author's Contributions

MMÖ: Writing - review & editing, Software; Supervision; Formal analysis; NU: Methodology; Investigation.

References

1 Faostat, FAO Statistical data, Food and Agriculture Organization of the United Nations, Rome (2018), http://www.fao.org/faostat/en/#data/QC

2 Ramadan M F, Improving the stability and radical-scavenging activity of sunflower oil upon blending with black cumin (*Nigella sativa*) and coriander (*Corinadrum sativum*) seed oils, *J Food Biochem*, 37 (2013) 286-295.

3 Shyu Y S & Hwang L S, Antioxidative activity of the crude extract of glycosides from unroasted Burma black sesame meal, *Food Res Int*, 35 (2002) 357-365.

4 Özcan M M, Endes Z & Er F, Physical and chemical properties of some seed and kernel oils, *Asian J Chem*, 22 (2010) 6531-6536.

5 Alyemeni M N, Basahy A Y & Sher H, Physico-chemical analysis and mineral composition of some sesame seeds (*Sesamum indicum* L.) grown in the Gizan area of Saudi Arabia, *J Med Plants Res*, 5 (2) (2011) 270-274.

6 Fukuda Y, Isobe M, Osowa T & Namiki M, Acidic transformation of sesamolin, the sesame oil constituent, into an antioxidant bisepoxylignan, sesaminol, *Heterocycles*, 24 (4) (1986) 923-926.

7 Joshi R, Kumar M S, Satyamoorthy K, Unnikrisnan M K & Mukherjee T, Free radical reactions and antioxidative activities of Sesamol: Pulse eadiolytic and biochemical Ssudies, *J Agric Food Chem*, 53 (2005) 2696-2703.

8 Terés S, Barceló-Coblijn G, Benet M, Alvarez R, Bressani R, *et al*., Oleic acid content is responsible for the reduction in blood pressure induced by olive oil, *Proc Nat Acad Sci USA*, 105 (37) (2008) 13811-13816.

9 El-Adawy T A & Mansour E H, Nutritional and physicochemical evaluations of tahina (sesame butter) prepared from heat-treated sesame seeds, *J Sci Food Agric*, 80 (2000) 2005-2011.

10 Anna Haug A, Hostmark A T & Harstad O M, Bovine milk in human nutrition – A review, *Lipids Health Dis*, 6 (2007) 25.

11 Yoshida H, Composition and quality characteristics of sesame seed (*Sesamum indicum*) oil roasted at different temperature in an electric oven, *J Sci Food Agric*, 65 (1994) 331-336 (1994).

12 Adebowale A A, Sanni S A & Falore O A, Varietal differences in the physical properties and proximate composition of elite sesame seeds, *World J Agric Sci*, 7 (1) (2011) 42-46.

13 El-Mallah M H, El-Shami S M, Hassanien M M M & Abdel-Razek AG, Effect of chemical refining steps on the minor and major components of cottonseed oil, *Agric Biol J North Am*, 2 (2) (2011) 341-349.

14 Hemalatha-Ghafoorunissa S, Sesame lignans enhance the thermal stability of edible vegetable oils, *Food Chem*, 105 (2007) 1076-1085.

15 Tokuşoğlu Ö, Zeytin (Olive), Gülermat matbaacılık, İzmir, 73-75 (2010).

16 ISO-International Organization for Standardization, Animal and vegetable fats and oils preparation of methyl esters of fatty acids, ISO, Geneve, Method ISO 5509, 1-6 (1978).

17 AOCS, Official Methods and Recommended Practices of the American Oil Chemists' Society, 2003, Methods Cd 3d–63, Cd 8b–90 and Ch 5–91, 5th edn. AOCS Press, Champaign (2003).

18 Püskülcü H & İkiz F, Introduction Statistic (İstatistiğe Giriş). Bilgehan Press, p 333, Bornova-İzmir, Turkey (1989), (in Turkish)

19 Allouche Y, Jimenez A, Gaforio J J, Uceda M & Beltran G, How heating affects extra virgin olive oil quality indexes and chemical composition, *J Agric Food Chem*, 55 (2007) 9646-9654.

20 Ramadan M F, Healthy blends of high linoleic sunflower oil with selected cold pressed oils: Functionality, stability and antioxidative characteristics, *Ind Crops Prod*, 43 (2013) 65-72.

21 Ramadan M F & Wahdan K M M, Blending of corn oil with black cumin (*Nigella sativa*) and coriander (*Coriandrum sativum*) seed oils: Impact on functionality, stability and radical scavenging activity, *Food Chem*, 132 (2012) (2) 873-879.