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Research Article

Determination of Effects Commercial Antioxidant and Essential Oil Additives on Some Physico-Chemical Properties of Olive Oil

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Abstract

In this study, the effects of several spice essential oil and some constituents on the oxidative stability of olive oil at 0.1% level of essential oils at 60 ºC was determined. Free fatty acid values of olive oil with different additives along at first-fourth weeks were changed between 1.61-2.01 %, 1.81-2.17 %, 1.67-2.23 %, 1.79-2.62 % respectively. Peroxide values of olive oil with different additives along at first-fourth weeks were changed between 11.98-15.10 meq O_2/kg, 15.48-19.64 meq O_2/kg, 18.22-27.50 meq O_2/kg, 18.70-39.60 meq O_2/kg respectively. Viscosity values of olive oil with different additives along at first- fourth weeks were changed between 39.90-55.45 m.Pas, 53.35-59.60 m.Pas, 33.10-54.70 m.Pas, 34.00-50.80 m.Pas respectively. The weakest antioxidant effect was determined in sater oil. Thujene exhibited the highest antioxidant effect, followed by eucalyptol, ocimene, myrtle-white, BHA (butylated hydroxyanisole), fennel and savory-sater essential oil respectively. Fatty acid compositions of olive oils had been partly affected from essential oil (0.1%) and some corresponding constituents (0.01%).Total amount of fatty acids changed between 96.86 % to 99.99 %. The most effected acids were linoleic acid, followed oleic and linolenic acids.

Keywords: Essential oil, BHA, antioxidant effect, peroxide value, viscosity, virgin olive oil.

Zeytinyağının Bazı Fiziko-Kimyasal Özellikleri Üzerine, Ticari Antioksidan ve Esansiyel Yağ Bileşenlerinin Etkilerinin Belirlenmesi

Öz

Bu çalışmada, 60ºC de birkaç baharat esansiyel yağının ve bazı bileşenlerin % 0.1 seviyesinde, zeytinyağının oksidatif stabilitesi üzerindeki antioksidan aktivitesi belirlenmiştir. Araştırma sonuçlarına göre, zeytinyağına farklı ilaveler ile yağın serbest yağ asitliği değerleri, birinci haftadan dördüncü haftaya kadar sırasıyla % 1.61-2.01, % 1.81-2.17, % 1.67-2.23, % 1.79-2.62 arasında değişmiştir. Peroksit sayısı değerleri, birinci haftadan dördüncü haftaya kadar sırasıyla 11.98-15.10 meq O_2/kg, 15.48-19.64 meq O_2/kg, 18.22-27.50 meq O_2/kg, 18.70-39.60 meq O_2/kg arasında değişmiştir. Viskozite değerleri, 39.90-55.45 m.Pas, 53.35-59.60 m.Pas, 33.10-54.70 m.Pas, 34.00-50.80 m.Pas arasında değişmiştir. Araştırmanın ilk haftasında yağın peroksit değerleri 11.98 meq O_2 / kg ile 15.10 meq O_2 / kg ($p<0.05$) arasında değişmiştir. En zayıf etki, sater yağında belirlenmiştir. Thujene en yüksek antioksidan etkiyi göstermiş olup, ardından okaliptol, ocimene, mersin beyazı, BHA (bütillenmiş hidroksianisol) ve rezene izlemiştir. Zeytinyağlarının yağ asidi bileşimleri, esansansiyal yağlardan (% 0.1) ve buna karşılık gelen bazı bileşenlerden (% 0.01) kısmen etkilenmiştir. Zeytin yağının toplam yağ asidi miktarı % 96.86 ile% 99.99 arasında değişmiştir. En çok etkilenen yağ asitleri linoleik asit, ardından oleik ve linolenik asitler olmuştur.

Anahtar kelimeler: Esansiyel yağ, BHA, antioksidan etki, peroksit değeri, sızma zeytin yağı, viskozite.

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1. Introduction

Olive oil has an important place in vegetable oils with its unique flavor (Erinç ve Kıralan, 2008). As well known, natural olive oil is obtained mechanically by pressing, centrifuging and filtering the olive fruits. In order to prevent oxidative degradation of this natural olive oil, it is necessary to store the oil in acid-inert equipment and at low temperature in such a way that it eliminates or minimizes contact with air and light and metal ions. (Türkan, 2008). Recently, the important of spices and herbs as natural antioxidants in foods is increasing. These effects are caused by antioxidant components in the content of the plant, such as flavonoids, essential oil components, plant phenolics (Nilsson et al., 2005; Tawaha et al., 2007; Salluca et al., 2008; Temitope et al., 2010; Rice-Evans et al., 1996; Özcan and Al-Juhaimi, 2011; Rice-Evans et al., 1997). Bioactive components of spices such as curcumin, zingerone, allicin are good antioxidant sources for lipid peroxidation (Nuutila et al., 2003; Noguchi et al., 1994). The use of synthetic antioxidants butylated hydroxyanisole (BHA), butylated hydroxytoluene (BHT) and tert-butyl hydroquinone (TBHQ) due to their potential health risks and toxicity is increasingly restricted (Moure et al., 2001). As far as our literature survey could as certain, scarce information was available on the antioxidant effect of both spice essential oils and some corresponding constituents on virgin olive oil. The objective of present study was to investigate the antioxidant effects of the essential oils and some their corresponding compounds on olive oil.

2. Material and Method

2.1. Material

The antioxidant effects were determined for all the spices and herbs (fennel bitter; myrtle-white, rosemary, oregano, laurel, basil, myrtle-black, mint, sage, savory sater in Table 1.) and five constituents (carvacrol, eucalyptol, ocimene, thujene and thymol) using peroxidation assay in model system. Five constituents (carvacrol, eucalyptol, ocimene, thujene and thymol) were provided 90-98% purities from by Sigma-Aldrich Corporation company (Merck). The olive oil was obtained from the North-West region of Saudi Arabia that commercial virgin olive oil. This oil did not contain food additive. BHA was used as a standard antioxidant for a comparison. The storage condition was carried out in a dark glass bottle in a cool and moisture-free environment for 4 weeks.

2.2. Method

2.2.1. Extraction of the essential oil

After dried and ground spices (about 100 g for each) were subjected to hydrodistillation for 3 h at 60ºC added average water 1:2 ratio using a Clevenger-type apparatus, the oils were dried over anhydrous sodium sulfate.

2.2.2. Physico-chemical analysis

All analyses (viscosity, free fatty acidity, peroxide number) were applied according to the AOCS (1990). The 0.01% BHA, 0.1% essential oil and 0.01% constituents were added directly into olive oil, and a solution was obtained by manual homogenisation (15 °C) for about 5 minutes. A control sample was prepared without addition of any antioxidant.

2.2.3. Determination of fatty acids

The fatty acid methyl esters were identified by comparing the retention time of the samples and appropriate fatty acids methyl esters standards Hışıl (1988). About 20 mg of sodium hydrogen sulphate (monohydrate, extra pure; Merck, Darmstadt, Germany) was added in samples and after centrifugation at 4500 rpm for 10 min, the top n-heptane phase was injected in a Gas Chromatography (Shimadzu GC-2010) equipped with a flame ionising detector (FID). The silica capillary column (RTX-2330, 100 m x 0.25 mm i.d.; film thickness 0.20 micrometer).

Working condition of GC, as follows;

Temperature
Column : 180°C
Enjector : 200°C
Dedector : 200°C
Flow
Carrier gas (N_2) : 30 ml/min.
Combustible gas (H_2) : 28 ml/min.
Dry air: 220 ml/min.
Printer: Chromatopac CR 6A (Shimadzu)
Enjection volume: 1µl

2.2.4. Statistical Analyses

A complete randomized split plot block design was used, 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 triplicate and the results are mean±standard deviation (MSTAT C) of independent spice and constituents (Püskülcü and İkiz, 1989).

Table 1. Plants used in experiment

Used plants	Name	Family	Used parts
Foeniculum vulgare L. ssp *piperitum*	Bitter fennel	Apiaceae	Fruit
Myrtus communis L. (with white fruit)	Myrtl	Myrtaceae	Leaves
Myrtus communis L.(with black fruit)	Myrtl	Myrtaceae	Leaves
Rosmarinus officinalis L.	Rosemary	Lamiaceae	Leaves +Flowers
Origanum minutiflorum L.	Oregano	Lamiaceae	Leaves +Flowers
Laurus nobilis L.	Laurel	Lauraceae	Leaves +Flowers
Ocimum basilicum L.	Basil	Lamiaceae	Leaves +Flowers
Mentha spicata L.	Mint	Lamiaceae	Leaves +Flowers
Salvia fruticosa L.	Sage	Lamiaceae	Leaves +Flowers
Satureja hortensis L.	Savory-sater	Lamiaceae	Leaves +Flowers

3. Results and Discussion

The effects on some physico-chemical properties (free fatty acidity, peroxide number, viscosity) of olive oil of some spice essential oils and corresponding constituents during storage are given in Table 2a and 2b.

According to our results, it was observed an important difference of the free fatty acid values of olive oil containing several spice essential oils and some corresponding constituents ($p < 0.05$) (Table 2a and 2b). While the free fatty acidity of samples at the first week was found between 1.61% (sage) to 2.01% (fennel and ocimene), at the second week, the free fatty acid values of olive samples were determined between 1.81% (thymol) to 2.37% (laurel). These values ranged from 1.67% (myrtle-white) to 2.23% (thujene) at the third week of experiment (Table 2b). At the last week, the free fatty acid values of olive oil samples containing essential oil and corresponding constituents were found between 1.79% (basil and thymol) to 2.62% (myrtle-black). As a result, the free fatty acidity of olive oil was not effected from essential oil and corresponding constituents. But, the free fatty acid values of the most of essential oils and constituents were found partly lower compared to control group.

Table 2.a. Changes at the peroxide values, free fatty acid and viscosity values of treated olive oil

Additives	1th Week			2th Week		
	Peroxide value (meq O_2/Kg)	**Free Fatty Acidity (oleic %)**	**Viscosity (m.Pas)**	**Peroxide value (meq O_2/Kg)**	**Free Fatty Acidity (oleic %)**	**Viscosity (m.Pas)**
Bitter fennel	12.95±1.17*d	2.01±0.21a	47.05±1.38ef	19.64±0.78a	1.86±0.11b	59.25±1.67b
Myrtl (white)	12.75±0.95d**	1.68±0.29e	39.90±0.98	15.80±0.76e	2.17±0.16a	58.25±1.43bc
BHA	12.91±0.78d	1.78±0.16d	54.45±1.51b	15.48±0.49e	1.83±0.21b	59.25±1.69b
Rosemary	13.79±1.21c	1.79±0.46d	51.60±1.67c	15.70±0.67e	1.83±0.13b	56.00±1.82cd
Carvacrol	14.78±1.33b	1.79±0.32d	45.25±1.19e	18.08±0.91b	1.98±0.15ab	53.35±1.71ef
Oregano	13.17±0.87c	1.82±0.21c	42.60±1.39f	18.53±0.84b	1.91±0.17ab	54.50±1.49e
Laurel	12.88±1.06d	1.78±0.18d	49.10±1.71d	17.09±0.82c	2.37±10.28a	58.90±1.56bc
Eucaliptol	12.12±1.15d	1.73±0.21d	46.20±1.65ef	16.45±0.38d	2.19±0.18a	58.15±1.67bc
Basil	13.40±1.29c	1.89±0.29c	55.45±1.52a	18.39±0.82b	2.12±0.16a	58.22±1.63bc
Thymol	14.11±1.19b	1.73±0.19d	49.10±0.98d	16.41±0.71d	1.81±0.16b	56.85±1.52cd
Myrtle (black)	14.51±1.17b	1.77±0.13d	53.80±1.29bc	15.93±0.81e	2.10±0.34a	58.95±1.59bc
Mint	14.83±1.36b	1.98±0.17ab	53.50±1.78bc	16.75±0.92d	2.07±0.29a	56.25±1.48cd
Ocimene	12.22±1.52d	2.01±0.28a	42.65±1.12f	16.42±1.01d	1.82±0.17b	59.00±1.62b
Sage	13.33±1.28c	1.61±0.15e	43.50±1.21f	16.23±1.09d	2.09±0.38a	55.85±1.39d
Savory sater	15.10±1.34a	1.84±0.17c	51.10±1.42c	16.33±0.96d	2.14±0.32a	57.50±1.53c
Thujene	11.98±0.79e	1.90±0.21ab	53.90±1.36bc	15.65±0.99e	2.10±0.39a	59.60±1.78b
Control	13.40±1.72c	1.67±0.11e	54.35±1.87b	15.46±0.78e	2.27±1.39a	62.00±1.78a

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p<0.05$)

Peroxide values of oil at the first week of experiment ranged from 11.98 to 15.10 meq O_2/kg. The effects of fennel, myrtl (white), BHA, oregano, laurel, eucalyptol, ocimene, sage and thujene were found partly higher compared to control group without food additive. The weakest effect was established in savory oil. Thujene exhibited the highest antioxidant effect, followed by eucalyptol, ocimene, myrtle-white, BHA and fennel. At the second week, it was observed an increase at the peroxide values. According to control group, both essential oils and their some constituents particularly stimulated peroxide values. The peroxide values of samples were determined between 15.46 to 19.64 meq O_2/kg. The highest peroxide value was recorded on olive oil with fennel essential oil. While this oil inhibited oxidation, it stimulated at the rate of about 49% at the second week. In addition, the effects of carvacrol, oregano and basil were weak on the stability of olive oil in 60°C ($p < 0.05$). The peroxide values of myrtle-white, BHA, myrtle-black and thujene were found partly similar compared to control group. At the 3rd week of experiment, the peroxide values of samples increased when compared with results of the first and second week. The highest peroxide value (27.5 meq O_2/kg) was established in olive oil containing carvacrol, followed by laurel (23.88 meq O_2/kg), myrtle-black (23.76 meq O_2/kg) and sage (21.57 meq O_2/kg) compared to control group (19.42 meq O_2/kg) and BHA (19.32 meq O_2/kg). The highest increase of the peroxide values of samples (except for mytrl-white) was observed at the 4rd

week of experiment. At the 4th week, peroxide values were determined between 18.70 to 39.60 meq O_2/kg. According to control group, the peroxide values of myrtle-white, BHA, eucalyptol and basil were found particularly low. In addition, peroxide value of fennel oil was found similar compared to control. Generally, the effects of both spices and corresponding constituents on oxidation of olive oil kept at 60 °C were found positive compared to control and BHA. At the same time, the most of constituents had more effects on the stability of olive oil compared to essential oils. Such as rosemary and sage oils are known antioxidants and find many applications in food preparations. Naturally occurring compounds in rosemary extracts have been reported to exhibit antioxidant properties greater than BHA and equal BHT (Wu et al., 1982; Ho et al., 1983, Özcan 1999). These differences may be probably due to phenolic compound structure of spice essential oils. In addition, it was observed statistically significant differences among peroxide value and viscosity values of olive oil treated with several spice and constituents compared to control group during storage periods ($p < 0.05$). It was observed a linear correlation between phenolic content and antioxidant activity in studies made by several researchers (Velioğlu et al., 1998; Gheldof and Engeseth., 2002; Oktay et al., 2003).

Table 2.b. Changes at the peroxide values, free fatty acid and viscosity values of treated olive oil

Additives	3th Week			4th Week		
	Peroxide value (meq O_2/kg)	**Free Fatty Acidity (oleic %)**	**Viscosity (m.Pas)**	**Peroxide value (meq O_2/kg)**	**Free Fatty Acidity (oleic %)**	**Viscosity (m.Pas)**
Bitter fennel	21.27±0.59b	1.96±0.19b	51.25±1.21d	26.73±0.45e	1.87±0.13	45.40±1.42bc
Myrtl (white)	19.61±0.32d	1.67±0.14d	52.95±1.17c	18.70±0.42h	1.94±0.15	44.60±0.98bc
BHA	19.32±0.59d	1.83±0.13c	52.45±1.27c	23.89±0.51g	1.88±0.21	43.10±1.21c
Rosemary	21.26±0.89b	1.79±0.29cd	51.00±1.29d	29.54±0.57cd	1.95±0.23	50.80±1.45a
Carvacrol	27.50±0.38a	1.90±0.21b	33.10±0.57h	39.60±0.28a	1.89±0.19	25.50±0.76g
Oregano	21.80±0.49b	1.95±0.27b	45.40±0.98f	33.90±0.32b	2.17±0.27	34.00±1.28f
Laurel	23.88±0.63b	1.73±0.18cd	47.20±0.82e	28.99±0.2d	1.93±0.18	42.70±1.53c
Eucaliptol	20.00±0.87b	2.13±0.19a	50.75±1.12de	25.22±0.19ef	1.86±0.19	41.60±1.57cd
Basil	18.22±0.58e	1.83±0.13c	53.22±1.37b	24.41±0.22ef	1.79±0.21	43.22±1.46c
Thymol	20.87±0.87c	1.80±0.23c	43.15±1.12g	29.13±0.43cd	1.79±0.41	35.20±1.27f
Myrtle (black)	23.76±0.78b	1.89±0.37c	47.95±1.21e	32.20±0.18bc	2.62±0.37	41.00±1.49d
Mint	20.00±0.89c	1.76±0.25cd	50.10±0.97de	27.85±0.27d	2.00±0.19	47.20±1.63b
Ocimene	19.90±0.67d	1.69±0.21d	54.70±1.11a	28.57±0.16d	1.87±0.49	46.00±1.34b
Sage	21.57±0.78b	1.69±0.22d	51.95±1.38d	30.70±0.45c	1.97±0.41	46.60±1.52b
Savory sater	21.27±0.94b	1.90±0.28b	42.05±1.27g	29.00±0.52cd	1.99±0.43	46.30±1.45b
Thujene	19.80±0.76d	2.23±0.38a	47.55±1.39e	30.71±0.46c	2.07±0.39	41.00±1.59e
Control	19.42±0.76d	1.94±0.16b	54.15±1.39a	26.15±0.32e	1.87±0.31	40.60±1.27ef

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p < 0.05$)

Generally, the viscosity values of olive oil contained essential oil and their constituents were found low when compared with results of control group up to 3rd week of experiment. But, at the 4th week (Table 2b), the viscosity values of samples partly decreased together with control group. While the viscosity values of olive oil samples changed between 39.90 m.Pas (myrtle-white) to 55.45 m.Pas (basil), at the 3rd week, these values varied between 33.10 m.Pas (carvacrol) to 54.70 m.Pas (ocimene). But, at the 4th week of experiment, the viscosity values were measured between 25.50 m.Pas (carvacrol) to 50.80 m.Pas (rosemary) ($p<0.05$). The viscosity values of carvacrol, oregano and thymol were found lower compared to control (40.60 m.Pas). Generally, the viscosity values of samples had probably changed depending on temperature, polimerization of oil and additives added into olive oil.

Table 3.a. The effect of some essential oil and constituents on fatty acid composition of olive oil (%)

Week	Additives	Fatty acid composition					
		Palmitic	**Oleic**	**Linoleic**	**Linolenic**	**Arachidic**	**Total**
1	Bitter fennel	7.80±0.19*c	75.77±10.01a	15.16±0.23c	1.25±0.06	-***	99.98
	Myrtl (white)	8.81±0.21b**	74.57±0.11b	13.51±0.34e	1.29±0.04c	0.66±0.03f	98.84
	BHA	7.90±0.23c	75.15±0.98a	14.87±0.26d	1.35±0.11a	0.70±0.07b	99.97
	Rosemary	9.10±0.32a	75.65±0.91a	13.93±0.37e	1.30±0.07b	-	99.98
	Carvacrol	8.50±0.38b	75.22±0.89a	13.74±0.21e	1.22±0.21h	0.69±0.06c	99.37
	Oregano	7.56±0.29c	75.67±0.71a	14.83±0.58d	1.25±0.17g	0.67±0.03e	99.98
	Laurel	9.00±0.27a	74.99±0.68b	12.85±0.41f	1.28±0.14d	0.68±0.05d	98.80
	Eucaliptol	7.70±0.21c	75.39±0.87a	14.76±0.53d	1.30±0.11b	0.70±0.11b	99.85
	Basil	6.82±0.42d	75.80±0.99a	15.35±0.25c	1.20±0.09h	0.70±0.13b	99.87
	Thymol	6.87±0.51d	75.03±0.78a	14.43±0.34d	1.22±0.09h	0.18±0.03ı	97.73
	Myrtle (black)	9.70±0.32a	75.34±077a	12.97±0.19f	1.26±0.09fg	0.69±0.07c	99.96
	Mint	6.70±0.28d	75.40±0.71a	16.37±0.23b	1.28±0.06d	0.22±0.03h	99.97
	Ocimene	7.80±0.19c	74.77±0.69b	14.61±0.21d	1.26±0.11fg	0.67±0.07e	99.11
	Sage	9.00±0.37a	75.52±0.67a	13.46±0.27e	1.29±0.09c	0.71±0.11a	99.98
	Savory sater	8.80±0.28b	74.97±0.56b	14.05±0.31d	1.27±0.17f	0.28±0.03g	99.37
	Thujene	5.79±0.37e	74.09±0.96b	17.09±0.23a	1.28±0.19d	-	98.25
	Control	7.60±0.56c	74.49±1.03b	15.04±0.16c	1.31±0.7ab	0.64±0.09	99.08

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p < 0.05$); ***nonidentified

The fatty acid composition of olive oil containing several essential oils and some their constituents are presented in Tables 3a, 3b ,3c and 3d. During experiment, palmitic acid values of samples were determined between 5.70% (mint at 4th week) to 9.21% (myrtle-black) at the 3th week. While palmitic acid values of olive oils at the first week of experiment ranged from 5.79% (thujene) to 9.70% (myrtle-white), these values changed between 6.01% (thujene) to 9.20% (sage) at the second week. In addition, while palmitic acid values were found between 6.49% (basil) to 9.20% (sage) at the 3th week, these values were established between 5.70% (mint) to 9.0% (myrtle-black and savory).

Results exhibited partly differences according to control group. It was not observed an important difference in oleic acid contents of olive oil samples contained essential oils and their constituents. The oleic acid contents of samples were found between 71.78% (savory at the first week) to 77.15% (mint at the last week).

Table 3.b. The effect of some essential oil and constituents on fatty acid composition of olive oil (%)

Week	Additives	Fatty acid composition					
		Palmitic	**Oleic**	**Linoleic**	**Linolenic**	**Arachidic**	**Total**
2	Bitter fennel	7.60±0.31c	74.21±0.73b	14.32±0.37c	1.30±0.31c	0.78±0.16c	98.21
	Myrtl (white)	7.81±0.29c	73.89±0.71c	14.52±0.39c	1.18±0.13g	0.86±0.07a	98.26
	BHA	7.34±0.27c	74.65±0.86b	15.36±0.41b	1.34±0.11b	0.38±0.03j	99.07
	Rosemary	8.81±0.25b	72.82±0.95d	13.47±0.38d	1.23±0.08e	0.68±0.06e	97.01
	Carvacrol	7.59±0.37c	74.62±0.83b	14.55±0.56c	1.20±0.07e	0.63±0.04g	98.59
	Oregano	7.21±0.41c	74.25±0.78b	15.26±0.47b	1.17±0.06g	0.78±0.11c	97.97
	Laurel	8.90±0.42b	75.42±0.72a	14.00±0.43c	1.27±0.05d	0.36±0.02j	99.95
	Eucaliptol	6.78±0.39d	75.38±0.88a	16.02±0.51a	1.28±0.08cd	0.52±0.06ı	99.98
	Basil	7.42±0.33c	75.66±0.86a	13.56±0.21d	1.41±0.11a	0.60±0.04h	98.65
	Control	7.26±0.37c	75.26±0.91a	15.50±0.29b	1.26±0.09d	0.71±0.07d	99.99
	Myrtle (black)	9.21±0.49a	73.96±0.94c	13.31±0.18d	1.29±0.16cd	0.49±0.03i	98.26
	Mint	6.81±0.35d	75.25±0.85a	15.52±0.38b	1.23±0.17e	0.55±0.03ı	99.36
	Ocimene	7.90±0.41c	75.78±0.93a	14.06±0.32c	1.26±0.31d	0.65±0.06f	99.61
	Sage	9.20±0.53a	75.81±0.69a	12.61±0.37e	1.22±0.21e	0.72±0.09d	99.56
	Savory sater	9.18±0.57a	74.93±0.78b	13.05±0.17d	1.19±0.05f	0.85±0.09ab	98.96
	Thujene	6.01±0.37d	75.53±0.77a	16.51±0.14a	1.28±0.07cd	0.65±0.03f	99.98
	Control	7.60±0.56c	74.49±1.03b	15.04±0.16c	1.31±0.7ab	0.64±0.09	99.08

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p < 0.05$); ***nonidentified

The oleic acid values of control group ranged from 74.49% to 75.36%. Linoleic acid contents of treated olive oils ranged from 10.75% (myrtle-black at the last week) to 17.09% (thujene at the first week). Linoleic acid values of olive oils with carvacrol, ocimene and thymol were found lower compared to control group during experiments.

Linolenic and arachidic acid contents of treated olive oils were identified under 1.5% level. Total amount of fatty acids changed between 96.86% to 99.99%. During storage, it was observed significant differences among palmitic, oleic and linoleic acid contents of olive oil compared to control group ($p<0.05$). As a result, fatty acid compositions of olive oils had been partly affected from essential oil (0.1%) and some corresponding constituents (0.01%).

Table 3.c. The effect of some essential oil and constituents on fatty acid composition of olive oil (%)

Week	Additives	Fatty acid composition					
		Palmitic	**Oleic**	**Linoleic**	**Linolenic**	**Arachidic**	**Total**
3	Bitter fennel	8.60±0.42b	75.98±0.84a	12.77±0.56d	1.17±0.06f	0.71±0.02d	99.23
	Myrtl (white)	6.81±0.38d	74.12±0.93b	14.29±0.42b	1.30±0.04c	0.34±0.03j	96.86
	BHA	7.80±0.39c	75.45±0.87a	14.20±0.37b	1.24±0.06d	0.67±0.06f	99.36
	Rosemary	8.80±0.81b	74.45±0.81b	12.76±0.32d	1.09±0.11g	0.69±0.09e	97.79
	Carvacrol	7.60±0.69c	74.88±0.83b	13.79±0.25c	1.05±0.07g	0.51±0.07i	97.76
	Oregano	8.01±0.71b	73.90±0.67c	14.05±0.27b	1.25±0.09d	0.92±0.09a	98.13
	Laurel	9.00±0.59a	75.12±0.94a	13.18±0.37c	1.09±0.03g	0.47±0.03ij	98.86
	Eucaliptol	7.10±0.42c	75.53±0.86a	15.22±0.33a	1.20±0.11d	0.60±0.07ı	99.65
	Basil	6.49±0.47d	74.90±0.82b	15.71±0.41a	1.60±0.16ab	0.38±0.03j	99.08
	Thymol	7.43±0.56c	74.73±0.69b	14.45±0.31b	1.13±0.09f	0.61±0.07ı	98.17
	Myrtle (black)	9.10±0.68a	73.90±0.85c	12.25±0.23d	2.01±0.26a	0.73±0.07c	97.99
	Mint	6.60±0.71d	75.37±0.89a	15.56±0.21a	1.22±0.18d	0.34±0.03j	99.09
	Ocimene	8.31±0.74b	74.69±0.85b	13.73±0.32c	1.32±0.11d	0.67±0.08f	98.72
	Sage	9.20±0.87a	75.49±0.99a	12.89±0.38d	1.19±0.09e	0.64±0.03h	99.33
	Savory sater	9.13±0.76a	71.78±0.87d	12.25±0.36d	1.65±0.21b	0.81±0.09b	94.81
	Thujene	6.71±0.59d	75.07±0.82a	15.14±0.27a	1.22±0.18d	0.67±0.05f	98.56
	Control	7.20±0.53c	75.36±0.78a	14.99±0.36b	1.20±0.17d	0.65±0.06g	99.40

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p<0.05$); ***nonidentified

The most effected acids were linoleic acid, followed oleic and linolenic acids. Chang et. al., (2013) have been determined the antioxidant activity of fennel seed extracts (FSE) was evaluated by synthetic antioxidant. During 28 days of storage, a compromise was accomplished based on the results assessed by peroxide value,at which the antioxidant activity of FSE was higher than BHA (75 ppm), BHT (75 ppm) and BHA to BHT ratio of 1:1 at the concentration of 150 ppm. Among them, concentration of 150 ppm showed the best antioxidant activity.

Another study was to investigate the effect of rosemary essential oil on the physico-chemical properties of extra-virgin olive oil. Free fatty acid and peroxide values of olive oils stored in different coloured bottles increased partly during storage. After 90 days of storage, free fatty acid values of samples changed between 0.78 and 0.89 mg KOH/g oil.

By the 90th day of storage peroxide values of samples had changed from 32.75 to 79.46 meq O_2/kg oil, whereas the peroxide value of the control group on the 90 th day was 94.55 meq O_2/kg. Linoleic acid (40.95-43.92%), oleic acid (33.04-34.99%) and palmitic acid (12.38-13.58%) were the major fatty acids of olive oils (Juhaimi et.al., 2015).

Table 3.d. The effect of some essential oil and constituents on fatty acid composition of olive oil (%)

Week	Additives	Fatty acid composition					
		Palmitic	**Oleic**	**Linoleic**	**Linolenic**	**Arachidic**	**Total**
4	Bitter fennel	8.43±0.81b	76.69±0.82b	12.83±0.18d	1.13±0.06bc	0.70±0.09d	99.78
	Myrtl (white)	7.11±0.97c	76.32±0.68b	14.43±0.31b	1.11±0.07c	0.69±0.11de	99.66
	BHA	7.20±0.85c	75.16±0.69c	14.23±0.21b	1.14±0.07b	0.68±0.16e	98.41
	Rosemary	7.90±0.71c	76.22±0.83b	13.10±0.18c	1.23±0.03a	0.59±0.05g	99.04
	Carvacrol	7.80±0.77c	76.56±0.96b	12.57±0.16d	1.01±0.06d	0.70±0.06d	98.60
	Oregano	8.00±0.89b	75.93±0.84c	12.60±0.28d	1.03±0.07d	0.79±0.09ab	98.35
	Laurel	7.90±0.81c	76.60±0.74b	13.51±0.26c	1.09±0.03d	0.69±0.03de	99.79
	Eucaliptol	7.00±0.88c	75.88±0.71c	14.58±0.31b	1.11±0.07c	0.66±0.03f	99.23
	Basil	6.65±0.54d	76.08±0.77b	15.36±0.39a	0.92±0.03	0.92±0.11a	99.93
	Thymol	7.43±0.74c	75.23±0.83c	13.07±0.31c	1.23±0.09a	0.68±0.06e	97.64
	Myrtle (black)	9.00±0.71a	76.74±0.92b	10.75±0.41e	1.12±0.08c	0.71±0.9c	98.30
	Mint	5.70±0.48e	77.15±0.84a	15.13±0.48a	1.10±0.05c	0.72±0.13b	99.80
	Ocimene	8.20±0.98b	76.98±0.77b	12.78±0.36d	1.13±0.09bc	0.71±0.09c	99.80
	Sage	8.00±0.76b	75.98±0.85c	13.23±0.31c	1.09±0.07d	0.69±0.06e	98.99
	Savory- sater	9.00±0.99a	76.11±0.79b	12.15±0.28d	1.10±0.06c	0.72±0.07b	99.08
	Thujene	5.80±0.67e	76.16±0.76b	15.45±0.23a	1.14±0.11bc	0.70±0.11d	99.25
	Control	6.90±0.51d	74.96±0.81d	14.06±0.37b	1.13±0.09bc	0.70±0.13d	97.75

*mean±standard deviation (n:3); **Values within each column followed by different letters are significantly different ($p<0.05$); ***nonidentified

Baiano et.al., (2010) showed that addition of some essential oils reduced lipid oxidation and showed an antioxidant effect when compared with the control group olive oil.

4. Conclusions and Recommendations

As a result, some spices and their some corresponding constituents have strong antioxidant effects (thujene, eucalyptol, ocimene, myrtle-white and BHA (butylated hydroxyanisole). These plant materials are expected to be a valuable food constituents for promoting good health in daily live. It can be concluded that essential oils extracted from these plants can supply a good opportunity as an antioxidant agent in food industry, if any sensory effects are acceptable. After these screening experiments, further works will be performed to describe the antioxidant in more details.

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