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Effects of some Aromatic Plant Oils on Thermo Oxidative Stability of Sunflower Oil

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ABSTRACT

This study was conducted in order to study the effect of adding essential oils extracted from natural sources (basil - caraway – rosemary leaves - lemongrass) where the total phenolic substances of the previous oils were estimated and the oxidative stability was studied using the Ransimat for sunflower oil treated with natural antioxidants and BHT as an antioxidant industrial, then heating for 16 hours. The results showed that essential oils contain a high percentage of phenols ranging from 5.65 to 17.56 mg / 100 grams.The induction times determined by the transducer for sunflower oil added to it 400 ppm of extracted essential oils were longer than those recorded when adding 200 ppm of rosemary, basil, and lemongrass, whose levels were highest. Caraway plant was the one that contained the lowest percentage of the concentration of total phenols, while rosemary, basil, and lemongrass had the highest levels (BHT). additionally, to regulate the use of essential oils for better, more efficient results, while being heated for 16 hours, the addition of essential vegetable oils to sunflower oil decreased oxidation and Therefore, the extracts of aromatic plants are an important and effective source of natural antioxidants, which can be used in food oils instead of industrial antioxidants because of their high health and nutritional benefits enhanced oxidative stability.Therefore, the extracts of aromatic plants are an important and effective source of natural antioxidants, which can be used in food oils instead of industrial antioxidants because of their high health and nutritional benefits.

Keywords: aromatic plant, phenolic components, oils, stability antioxidants

INTRODUCTION

Essential oils are aromatic, unstable, hydrophobic, highly concentrated substances found in aromatic plants (or volatile or ether oils). It can be harvested from a variety of plant parts, including the flowers, buds, seeds, leaves, twigs, bark, wood, end product, and roots. Oils are frequently extracted by steam distillation, and at this moment, supercritical carbon dioxide extraction is the most popular method. Kristaki *et al* (2012). Essential and medicinal oils are extremely potent, delicately healing volatile molecules that are extracted from known, particular components of specific plant species. (Butnariu and Sarac. 2018). Many aromatic and therapeutic plants have been used, produced, and traded in Egypt for a very long time. These numerous crops are utilised in a wide range of industries as raw or processed commodities (for instance, as dried spices or essential oils to flavour candy, baked goods, degrade products, marinate meats, sausages, etc.) (Faydaoğlu and Sürücüoğlu 2011). In recent years, there has been an increase in interest in using conventional chemicals rather than transgenic elements to alter the fat-containing legumes. The concentrated form of spices like basil, caraway, rosemary, and lemongrass are among the natural cell-boosters. Plants were frequently used as remedies in primitive times. Human understanding of the nutritional value of edible plants expanded, it was also discovered that some plants, including some edible plants, can have therapeutic effects (Shabbir 2012). Medicines are often derived from medicinal and aromatic plants (MAPs). Many of them have not been utilised to their full capacity in the medical and pharmaceutical areas, although having immense promise. (Paramania *et al*., 2020). Another noteworthy biological benefit of essential oils is their antioxidant activity, which protects the majority of constituents from the harmful effects of oxidants (Maestri *et al* 2006). In addition, essential oils can play an important role in preventing a variety of diseases, including diseases of the deteriorating immune system, cancer, heart disease, and brain disorders. More and more data indicate that the majority of these diseases can be caused by free radicals that damage a mobile device (Aruoma 1998). The chemical composition of medicinal and aromatic essential oils, in particular, affects their antioxidant capacity. Phenols and other secondary metabolites are linked by double bonds responsible for the massive antioxidant activity of the important oils (Koh, *et al*. 2002).

The aim of this research is to know the antioxidant activity of medicinal and aromatic oils and their controversial use of industrial antioxidants as a preservative when added to sunflower oil.

MATERIALS AND METHODS

Materials:

Aromatic plants:

Four selected dried aromatic plants, namely: basil (*Ocimum basilicum*), caraway (*Carum carvi*), rosemary (*Rosmarinus officinalis*), and lemongrass (*Cymbopogon citratus* L.) were obtained from a private farm in Aswan

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Refined sunflower oil:

Refined sunflower oil free from antioxidant was obtained from Oil-tech Company for oils and detergents, Sadat City -Menoufia Governorate, Egypt.

Butylated Hydroxy Toluene (BHT):

Butylated Hydroxy Toluene (BHT) was purchased from Sigma Chemical Company (St. Louis, USA).

Methods:

Aromatic plant oil extraction:

By using the Clevenger apparatus, basil The broken leaves of basil, crashed seeds of caraway, damaged leaves of rosemary and broken leaves of lemongrass could be extracted for their essential oils as described by Semeniuc *et al*. (2017). After 4 h of distillation, the unstable oil solidified into a clump (at which point the maximum amount of essential oil was obtained). Before being used, the isolated volatile oil was dehumidified using anhydrous sodium persulfate and kept in glass vials at -18 °C.

Determination of essential oil content:

The essential oil composition was determined in accordance with the method described in Mahdavi, *et al* (2016). Damaged basil leaves, crushed caraway seeds, broken rosemary leaves, and damaged lemongrass leaves were placed in a 1L flask, which was then filled to half with water. The flask's contents were cooked until the unstable oils were completely separated from the plant material, at which point the amount of oils in the graduated tube became red. The quantity/weight ratio was used to compute the percentage of each unstable oil.

Determination of fatty acids in fixed oils extracted from medicinal and aromatic plants..

The GC-MS machine (Agilent Technologies) becomes prepared with gas chromatograph (7890B) and mass spectrometer detector (5977A) at Central Laboratories Network, National Research Centre, Giza, Egypt. Samples had been diluted with hexane (1:19, v/v). The GC was equipped with HP-5MS column (30 m x 0.25 mm inner diameter and 0.25 µm film thickness). Analyses were accomplished the usage of hydrogen as the carrier fuel at a drift charge of 1.0 ml/min at a cut up 1:20 of, injection extent of 1 µl and the following temperature application: 40 °C for 1 min; growing at 4°C /min to 150°C and held for 6 min; rising at 4°C/min to 210°C and held for 1 min. The injector and detector were held at 280°C and 220 °C, respectively. Mass spectra were obtained by way of electron ionization (EI) at 70 eV; the usage of a spectral range of m/z 50 -550 and solvent put off four min. Identification of different ingredients turned into determined via evaluating the spectrum fragmentation pattern with the ones stored in Wiley and NIST Mass Spectral Library data (Valdez *et al*., 2019).

Physical and chemical properties of extracted essential oils:

Acid value, iodine value, peroxide value and TBA values were estimated according to AOAC (2010).

Total extraction of polyphenols:

After being distilled, plant material was dried for 48 hours at 35°C (until it reached a constant weight), and then it was strained to remove byproducts via a 2-mm screen. Prior to allowing the samples to air dry at ambient temperature, 20 mL of petroleum ether was first extracted while agitating the dried samples (0.5 g). Second, they were extracted in a Soxhlet extractor (B-811) for 2 hours in a nitrogen environment with 150 mL of methanol (Buchi, Flawil Switzerland). At 40 °C under vacuum, methanolic extracts have been evaporated (using Syncore Polyvap R-96) to dryness . In order to make 5mL, the residual fabric was once more altered and dissolved in methanol. The dry weight per mL of solvent used to express the concentration of the extracts was. The extracts were kept in vials at −80°C until their corresponding analysis.

Total polyphenol content:

Phenolics content was estimated using Folin-Ciocalteu colorimetric method as described by Michiu *et al*., (2022). The absorbance of the resulting blue color was measured at 750 nm with a Shimadzu spectrophotometer. Quantification was done with respect to the standard curve of gallic acid. The results were expressed as gallic acid/100 g dry weight.

Antioxidant activity:

Antioxidant activities of the studied aromatic plant oils compared with synthetic antioxidant (BHT) were determined with a Rancimate apparatus (Metrohm, Herisau, Switzerland) by measuring the induction period of oils containing the antioxidant, according to the method described by Farahmandfar *et al.*, (2018).

The antioxidant index was calculated as:

Antioxidant index = Induction period of heated oil / Induction period of oil.

Thermal treatment of sunflower oil:

The food additive regulation in USA had a certain limit of 200 ppm of industrial antioxidant (BHT), while others of natural antioxidants had 400 ppm of essential oils as a recommended usage degree (Holmes *et al*, 2021). The two antioxidants used were within the recommended usage levels as previously mentioned and they are synthetic antioxidant)BHT(and natural antioxidants)medicinal and essential oils under study(. Antioxidants were dissolved in 250 ml sunflower oil and kept in brown glass bottles. Then the sunflower oil samples were heated at 180°C±5°C for 16 h at intervals of 2 h heating. The heated oils were sampled every day after heating in brown bottles and kept at 5°C for analytical experiments.

Statistical analysis:

IBM SPSS Statistics 25, C statistical programme was used to conduct the statistical analysis. To evaluate significant differences between means at 5% levels of probability, the LSD Multiple Range Test was used. The results were expressed as means standard error for each experiment that was performed in duplicate. Additionally, one-way ANOVA statistical analysis was used to detect significant differences at the 5% and 1% levels (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

Yield of extracted essential Oils

Using a specially created Clevenger apparatus, the essential oil was extracted from rosemary, basil, lemongrass, and caraway seeds. The essential components of an important oil are regarded to be best extracted by hydro distillation. That is also one of the appropriate ways, in addition. With the help of caraway, basil, and then lemongrass, researchers found that the oil from rosemary

performed the best when compared to the rest of the study plants, as indicated in Table (1).

Table 1. percentage of extacted oil in rosemary, caraway, basil and lemongrass:

Aromatic plants	Rosemary leaves	Basil leaves	Caraway seeds	Lemongrass leaves
% Essential oil	1.5%	0.42%	1.4%	0.34%

Regarding the proportion of essential oils extracted from rosemary, basil, lemongrass and caraway plants on a dry weight basis were (1.5%, 0.42%, 1.4%, 0.34%; respectively), they were within the ranges reported by SIMS *et al*. (2014) , Laribi, B *et al* (2013) , Conde-Hernández, L. A *et al*. (2017) and Soliman, W. S *et al* (2017).

Composition of medicinal and aromatic plants fixed oils

Table 2 demonstrate the chemical makeup of fixed oils from aromatic plants. It is clear that the fixed oils are distinguished by their reasonable inclusion of fatty acids, both saturated and unsaturated, with substantial oleic acid concentration in all samples. In the examined oils, volatile organic hydrocarbon molecules have also been discovered with unusual frequency.

The results in Table (2) reavealed that fixed basil oil contain many saturated and unsaturated fatty acids. Both oleic (40.58%) and linoleic (13.17%) acids were present as unsaturated acids in higher quantities than myristic and stearic acids as saturated, as well as, the volatile organic hydrocarbons was found in different quantities like phytol and methyleicosane with values 18.67; 3.13%, respectively. These results are consistent with findings of Veronezi *et al*., (2014).

Estimating the amounts of saturated and unsaturated fatty acids was done through the study of the fixed oil from caraway seeds. Oleic acid (49.84%) and linoleic acid (36.57%) were found to have the greatest values for unsaturated fatty acids, respectively, whereas palmitic acid (8.54%) and stearic acid (2.6%) had the lowest values for saturated fatty acids. Additionally, squalene, a volatile organic hydrocarbon, was discovered in quantities as low as 0.38 percent. These findings also somewhat agreed with those of Laribi *et al* (2010).

Table (2) displays the findings of the analysis of fixed rosemary oil, which revealed that oleic acid (40.74%), palmitic acid (13.42%), and linoleic acid (12.95%) were the fatty acids present in the largest concentrations when compared to the other acids. Among the examined acids in the oil, myristic acid was the least abundant. Additionally, certain volatile organic hydrocarbons were discovered, with phytol having the greatest concentration of any of them (18.24%), followed by caryophyllene, methylicosan, and germacrin D. These findings partially agreed with those of Yang *et al* (2016).

The findings in Table (2) showed that different fatty acids are present in lemongrass leaves fixed oil in varying amounts, with oleic acid (32.02%) having the greatest concentration of all the acids. In comparison to oleic acid, palmitic acid (17.11%) and linoleic acid (10.88%) had lower contents with values of 17.11% and 10.88%, respectively. Tridecene (2.49%) and phytol (6.15%) are two more volatile organic compounds that were detected. With Duru and Enyon (2020), this product came out differently.

Table 2. The components (%) of basil leaves, caraway seeds, rosemary leaves and lemongrass leaves fixed oil fractionated by gas chromatography (GC-MS).

Aromatic plant	Components				
	Fatty acid (F.A)	Carbon: chain	%	Volatile organic hydrocarbon	%
basil leaves fixed oil	Myristic acid	C14:0	1.12	β-Bourbonene	1.3
	Palmitic acid	C16:0	13.62	Caryophyllene	2.42
	Stearic acid	C18:0	3.03	Germacrene D	0.84
	Oleic acid	C18:1	40.58	Phytol	18.67
	Linoleic acid	C18:2	13.17	Methyleicosane	3.13
	Arachidic acid	C20:0	2.12		
caraway seeds fixed oil	Palmitic acid	C16:0	8.54	Squalene	0.38
	Plmitoleic	C16:1	0.62		
	Stearic acid	C18:0	2.6		
	Oleic acid	C18:1	49.84		
	Elaidic acid	C18:1 trans	0.45		
	Linoleic acid	C18:2	36.57		
	Arachidic acid	C20:0	0.39		
	Gadoleic	C20:1	0.6		
rosemary leaves fixed oil	Myristic acid	C14:0	1.08	Caryophyllene	2.4
	Palmitic acid	C16:0	13.42	Germacrene D	0.82
	Stearic acid	C18:0	3.02	Phytol	18.24
	Oleic acid	C18:1	40.74	Methyleicosane	2.34
	Linoleic acid	C18:2	12.95		
	Arachidic acid	C20:0	2.08		
lemongrass leaves fixed oil	Myristic acid	C14:0	1.08	Tridecene	2.49
	Palmitic acid	C16:0	17.11	Phytol	6.15
	Stearic acid	C18:0	4.69		
	Oleic acid	C18:1	32.02		
	Linoleic acid	C18:2	10.88		
	Arachidic acid	C20:0	2.31		

Total phenolic contents:

Table (3) shows the total phenolic contents determined by the Folin-Ciocaltue method in oil samples of the examined aromatic plants. The amount of total phenolics in the examined aromatic plants ranged from 5.65 to 17.56 mg of gallic acid/100 g of dry weight.

Caraway had the lowest concentration of total phenols content, whereas rosemary had the greatest concentration of total phenols. The high polyphenol content of the spice was further supported by the findings of the current investigation. The order of the investigated spices' phenolic contents could be arranged as follow rosemary > basil > lemon > caraway. The apparent variations across plants are caused by genetic and ecological variations within species, the variety of the components under investigation, as well as the sample period (Hejazi *et al* 2012, Ahmed *et al* 2019, Mirghani *et al* 2012).

Table 3. Phenolic content (mg gallic acid / 100g dry weight) in aromatic plants.

Aromatic plants	Rosemary leaves	Basil leaves	Caraway seeds	Lemongrass leaves
Phenolic content	17.56	15.76	5.65	7.62

Antioxidant stability of sunflower oil with anti-oxidant:
antioxidant activities of studied aromatic plant extracts are presented in Table (4). The Rancimat apparatus was used to assess the antioxidant activity of essential oils derived from rosemary, basil, caraway, and lemongrass. The induction duration for the onset of oxidative rancidity in sunflower oil at 110 °C was established using this method, and the longer induction period shows a better antioxidant activity. In this study, redox activity was assessed using a straightforward model system made of edible sunflower oil and an essential oil. In order to evaluate the antioxidant effectiveness of the natural essential oils under study with the most widely used synthetic antioxidants, this experiment involved treating sunflower oil with BHT (200 ppm).

Table (4) displays how rosemary, basil, caraway, and lemon plant essential oils affect the oxidative rancidity of sunflower oil. The antioxidant phenomenon was demonstrated using sunflower oil without any additives and sunflower oil infused with BHT (200 ppm) in order to compare the antioxidant effectiveness of various natural antioxidants. The findings thus demonstrated that all of the investigated essential oils exhibited antioxidant activity. Additionally, all of the natural oils under study had longer induction periods than plain sunflower oil.

This implies that all supplemental medicinal and essential oils have an antioxidant effect when added to sunflower oil. According to the aforementioned findings, the investigated essential vegetable oils have a high concentration of phenolic compounds, which can prevent sunflower oil from auto-oxidizing and minimise oil peroxidation (Ben Ali *et al*., 2014). These findings substantially agreed with those provided by Politeo *et al* (2006). Contrarily, the induction times and antioxidant activity of sunflower oils treated with the investigated essential oils reflected the levels of total phenols in the oils, which are shown in Table No. (4).

Table 4. Effect of oxidative stability of treacted sunflower oil with antioxidant:

Sample system	Induction period (hr)	Antioxidant activity
Sunflower oil (Control)	3.62	-
Sunflower oil + basil oil	4.18	1.15
Sunflower oil + caraway oil	3.89	1.07
Sunflower oil + Rosemary oil	6.79	1.89
Sunflower oil +lemongrass oil	3.90	1.08
Sunflower oil + BHT	3.78	1.04

Antioxidative effect of aromatic plant oils on the stability of sunflower oil during heat treatments:

The chosen refined vegetable oil for the study was sunflower oil. This oil was chosen because it is frequently used for frying and has a high proportion of unsaturated fatty acids that interact with oxygen. Without the use of any synthetic antioxidants, sunflower oil is refined, bleached, and deodorised to attain its final state. The initial characteristics of the sunflower oil utilised in this study were evaluated by determining the levels of acidity number, peroxide number, iodine number, and TBA value as given below. (Aldaline *et al*. 2011).

Studies show that sunflower oil without antioxidants are more prone to deterioration after heating than edible oils that do include antioxidants, as shown by significant increases in the acid value of crude sunflower oil without heater additions (Table 5). At the conclusion of the heating period, the values for the comparison plant, BHT, caraway, lemon, rosemary, and basil oils were 2.82, 2.05, 2.10, 1.98, 1.96, and 2.06%, respectively. In other studies, a vegetable essential oil extract decreased the generation of free fatty acids during heating. (Amari *et al*. 2012 and Olmedo *et al*., 2015).

Table 5. Changes of acid value for heated sunflower oil of essential or natural antioxidants during thermal process.

Heating periods (hours)	Sunflower oil samples plus					
	Control	BHT	Caraway	lemongrass	Rosemary	Basil
Zero	٠,٨7±0.06^{a}	٠,٨٧ ±0.07^{a}	٠,٠٢^{a}٠,٨٧±	٠,٠٦^{a}٠,٨٧±	٠,٠٦^{a}٠,٨٧±	٠,٠٢^{a}٠,٨٧±
2	١,١٧ ±0.08^{a}	١,١٠ ±0.06^{ab}	١,٠٢ ±0.05^{ab}	١,٠٦ ±0.06^{ab}	٠,٩٨ ±0.01^{b}	١,١٨ ± 0.04^{a}
4	١,٣٥ ±0.05^{a}	١,٢٢ ±0.05^{abc}	١,١٦ ±0.04^{bc}	١,١٣ ±0.05^{bc}	١,٠٨ ±0.06^{c}	١,٢٨ ±0.04^{ab}
6	١,٤٨ ±0.01^{a}	١,٣٨ ±0.02^{ab}	١,٢٨ ±0.03^{bc}	١,٢١ ±0.02^{c}	١,٤١ ±0.03^{a}	١,٤١ ±0.06^{a}
8	١,٦٩ ±0.02^{a}	١,٥٠ ±0.04^{b}	١,٣٩ ±0.01^{c}	١,٣٥ ±0.03^{c}	١,٣١ ±0.04^{c}	١,٥٣ ±0.04^{b}
10	١,٩٣ ±0.03^{a}	١,٧٤ ±0.03^{b}	١,٦٢ ±0.04^{cd}	١,٦٥ ±0.06^{bcd}	١,٥٨ ±0.01^{d}	١,٧١ ±0.02^{bc}
12	٢,١٤ ±0.05^{a}	١,٨٤ ±0.02^{b}	١,٧٨ ±0.09^{b}	١,٨١ ±0.04^{b}	١,٦٩ ±0.01^{b}	١,٨٥ ±0.04^{b}
14	٢,٥٦ ±0.03^{a}	١,٩٣ ±0.03^{bc}	١,٩٧ ±0.02^{b}	١,٩١ ±0.01^{bc}	١,٨٠ ±0.05^{c}	١,٩٧ ±0.10^{b}
16	٢,٨٢ ±0.07^{a}	٢,٠٥ ±0.06^{b}	٢,١٠ ±0.04^{b}	١,٩٨ ±0.01^{b}	١,٩٦ ±0.03^{b}	٢,٠٦ ±0.06^{b}

MS= Mean Square SE= Standerd Error

Means with different letters (a, b, c, d) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

This indicates that the natural antioxidants present in the extracted essential oil can protect sunflower oil from hydrolysis more effectively than BHT . Additionally, the iodine value was determined during heat treatment, and in all of the analysed samples, a steady reduction in unsaturation was seen (Table 6). Through the oxidation, cleavage, and polymerization reactions that break down the double bonds, it can be extracted from this decrease (Al-Kashif *et al*., 2014). According to information, heating oil drastically decreased iodine values. As a result of the

removal of hydrogen from close to the double bond and the production of free radicals, the oxidation processwhich is made up of several intricate chemical reactions decreased the total unsaturated content of the oil. Heating that promoted oil oxidation caused a maximum reduction in iodine levels as a result. (Abd-El Ghany *et al*., 2010).

Table 6. Changes of Iodine value for heated sunflower oil of essential or natural antioxidants during thermal process.

Heating periods (hours)	Sunflower oil samples plus					
	Control	BHT	Caraway	lemongrass	Rosemary	Basil
Zero	١٢٣,٥٦ ±0.07^{a}	١٢٣,٥٦ ± ٠,٢٩^{a}	٠,٠٩^{a}١٢٣,٥٦±	٠,٠٢^{a}١٢٣,٥٦±	٠,٠٨^{a}١٢٣,٥٦±	٠,٠٨^{a}١٢٣,٥٦±
2	١٢٢,٠٢ ±0.26^{a}	١٢٢,١٢ ±0.31^{a}	١٢٢,٣٢ ±0.08^{a}	١٢٢,٢٤ ±0.01^{a}	١٢٢,٣٦ ±0.06^{a}	١٢٢,٤١ ±0.07^{a}
4	١٢٠,١٥ ±0.09^{c}	١٢١,١١ ±0.06^{b}	١٢١,٢٦ ±0.07^{b}	١٢١,١٨ ±0.11^{b}	١٢١,٨٨ ±0.33^{a}	١٢١,٠٨ ±0.08^{b}
6	١١٨,١٢ ±0.05^{d}	١٢٠,٠٤ ±0.08^{b}	١١٩,٦٨ ±0.04^{c}	١٢٠,١١ ±0.11^{b}	١٢٠,٩٠ ±0.04^{a}	١٢٠,١٢ ±0.08^{b}
8	١١٧,٣٦ ±0.06^{d}	١١٩,٣٨ ±0.11^{a}	١١٨,١٦ ±0.22^{c}	١١٨,٨٢ ±0.15^{b}	١١٩,٤٦ ±0.09^{a}	١١٩,٨١ ±0.16^{a}
10	١١٥,٤٤ ±0.05^{e}	١١٨,١٦ ±0.04^{bc}	١١٧,٨٢ ±0.13^{d}	١١٨,٠٣ ±0.09^{cd}	١١٨,٧٢ ±0.15^{a}	١١٨,٤٤ ±0.08^{ab}
12	١١٤,٣٣ ±0.06^{d}	١١٧,٦٠ ±0.09^{b}	١١٧,١١ ±0.17^{c}	١١٦,٨٨ ±0.11^{c}	١١٨,٠١ ±0.09^{a}	١١٧,٧٦ ±0.07^{ab}
14	١١٣,٢١ ±0.13^{d}	١١٦,٢٦ ±0.17^{c}	١١٦,١٣ ±0.12^{c}	١١٦,١١ ±0.18^{c}	١١٧,٦٦ ±0.08^{a}	١١٦,٧٤ ±0.17^{b}
16	١١١,١٥0±0.29^{e}	١١٥,٧٢ ±0.15^{bc}	١١٤,٩٢ ±0.06^{d}	١١٥,٨٤ ±0.11^{b}	١١٦,٨ ±0.09^{a}	١١٥,٢٤ ±0.16^{cd}

MS= Mean Square SE= Standerd Error

Means with different letters (a, b, c, d,e) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

The value of peroxide produced in sunflower oil after heating for up to 16 hours is shown in Table (7). And it was found that the peroxide values reduced after the heating times were increased to 12 hours. This might be due to the different rates at which peroxide is produced and broken down. With rising temperature, peroxide synthesis started to outpace peroxide decomposition. However, as the heat increased, decomposition took place. The effects of adding antioxidants (BHT and extracted essential plant oils) on the oil's peroxide value were assessed after heating the sunflower oil for up to 16 hours. The findings demonstrated that when compared to sunflower oil without antioxidants,, all of the antioxidants examined significantly slowed the rate of oxidation in the oil. These results are consistent with those reported (El-Kashef *et al*, 2014).

Table 7. Changes of peroxid value for heated sunflower oil of essential or natural antioxidants during thermal process

Heating periods (hours)	Sunflower oil samples plus					
	Control	BHT	Caraway	lemongrass	Rosemary	Basil
Zero	١,١٦ ±0.12^{a}	١,١٦ ±0.03^{a}	0.04^{a}١,١٦±	0.06^{a}١,١٦±	0.04^{a}١,١٦±	0.20^{a}١,١٦±
2	٢,٦٥ ±0.05^{a}	٢,٣٢ ±0.010^{b}	٢,٢٤ ±0.08^{b}	٢,١٨ ±0.05^{b}	٢,١١ ±0.06^{b}	٢,٣٣ ±0.06^{b}
4	٤,٢٣ ±0.12^{a}	٣,٥٥ ±0.06^{b}	٣,٦٢ ±0.05^{b}	٣,٦٥ ±0.05^{b}	٣,١٥ ±0.04^{c}	٣,٤٨ ±0.13^{b}
6	٦,١٤ ±0.06^{a}	٥,١٦ ±0.29^{b}	٤,٩٢ ±0.03^{b}	٤,٧٣ ±0.06^{bc}	٤,٢٥ ±0.27^{c}	٤,٨٢ ±0.02^{b}
8	٨,٩٢ ±0.06^{a}	٧,٢٢ ±0.13^{bc}	٧,١١ ±0.11^{bc}	٧,٢٦ ±0.13^{b}	٦,١٢ ±0.08^{c}	٦,٩٢ ±0.06^{d}
10	١٠,٣٥ ±0.06^{a}	٩,١٧ ±0.33^{b}	٩,٥٦ ±0.08^{b}	٩,٣٣ ±0.05^{b}	٨,٢٦ ±0.14^{c}	٩,١٢ ±0.09^{b}
12	١٢,٥٦ ±0.06^{a}	١١,٨٢ ±0.07^{b}	١٠,٥٨ ±0.09^{e}	١١,٤٥ ±0.08^{c}	٩,٩٢ ±0.07^{f}	١٠,٩٦ ±0.08^{d}
14	١٠,١٧ ±0.03^{b}	١٠,١٢ ±0.05^{bc}	٨,٢٢ ±0.08^{e}	٩,٨٨ ±0.08^{c}	١٠,٨٨ ±0.09^{a}	٩,٢٢ ±0.12^{d}
16	٧,٣٥ ±0.05^{c}	٧,٢٦ ±0.11^{c}	٧,١٥ ±0.12^{c}	٨,٥٨ ±0.09^{b}	٩,١١ ±0.10^{a}	٧,٢٦ ±0.05^{c}

MS= Mean Square SE= Standerd Error

Means with different letters (a, b, c, d,e.f) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

The peroxide test cannot be relied upon infallibly to determine the degree of rancidity of oils and fats because cracking occurs, which gives inaccurate results when linking peroxide values to the sensory characteristics of oils and degrees of rancidity. Therefore, a TBA test was required, where this test is used as an indication of the presence of oxidation. It is based on an examination of the aldehyde molecules created when hydroperoxides dissolve, which gives out an odour that people find repulsive. Malonaldehyde is detected as a byproduct of lipid oxidation. A spectrophotometer can recognise the coloured molecule that results from the reaction of malonaldehyde with TBA. Table (8), which demonstrated how the TBA value in samples of sunflower oil gradually increased while heating for up to 16 hours. TBA levels are increasing, which indicates the formation of carbonyl compounds. Heating in the presence of air resulted in the formation of these chemicals. The amount of these compounds produced may depend on the type of oil utilised and the heating methods employed. These results are in agreement with those of Al-Dalain *et al* (2011). The addition of antioxidants to sunflower oil was very advantageous since the TBA values after 16 hours of heating were significantly lower than the values of the oil without antioxidants.

According to the aforementioned findings, it is possible to infer that the aromatic plant oils that were extracted have antioxidant qualities and would be employed as an alternative to synthetic antioxidants in a variety of food applications. Furthermore, it could be said that the researched aromatic plant oils included a lot of phenolic elements and had strong antioxidant properties.

It is clear from Table (9) that there are significant statistically significant differences between the treatments when comparing the effect of natural antioxidants and industrial antioxidants according to the variables which are the number of hours of heating. Where significant differences were found at 0.05 for each of the value of acids at 4 and 6 hours of heating and for the value of peroxide at 2 hours of heating, and the value of TBA at 2 hours of heating. High significant differences were found at 0.01 for each of the value of acids at the number of hours of heating 8, 10, 12, 14, 16 hours of heating and the value of iodine at the total heating time heating for 4,6,8,10,12,14, and 16 h Additionally, the value of peroxide at 4, 6, 8, 10, 12, 14, and

16 h of heating as well as the value of TBA at 8, 10, 12, 14, and 16 h of heating.

According to the previous findings, there are substantial variations between the treatments for the added medicinal and aromatic oils, which resulted in higher stability with an increase in the number of heating hours, at 0.05 and 0.01 respectively.

Overall, the findings indicated that the aromatic herbs had high phenolic content and strong antioxidant activity. These plants, which are high in phenolic components, may be a useful source of phenolic compounds. Therefore, it may be possible to explain the correlations between the total antioxidant capacity and the total phenolic contents in the aromatic plants by doing qualitative and quantitative analyses of the primary individual phenolics in those plants.

Table 8. Changes of Thiobarbiturice acid value for heated sunflower oil of essential or natural antioxidants during thermal process.

Heating periods (hours)	Sunflower oil samples plus					
	Control	BHT	Caraway	lemongrass	Rosemary	Basil
Zero	٠,٧٤ ±0.06^{a}	٠,٧٤ ±0.10^{a}	0.06^{a}٠,٧٤±	0.03^{a}٠,٧٤±	0.09^{a}٠,٧٤±	0.08^{a}٠,٧٤±
2	٠,٩١ ±0.04^{a}	٠,٨١ ±0.03^{a}	٠,٧٩ ±0.09^{a}	٠,٨١ ±0.05^{a}	٠,٨٠ ±0.10^{a}	٠,٣٨ ±0.05^{b}
4	١,١٢ ±0.09^{a}	١,٠٣ ±0.07^{a}	٠,٩٨ ±0.01^{a}	٠,٩٦ ±0.01^{a}	٠,٩٧ ±0.03^{a}	١,٠٤ ±0.11^{a}
6	١,٥٣ ±0.12^{a}	١,٤١ ±0.04^{ab}	١,٣٥ ±0.03^{ab}	١,٢٣ ±0.07^{b}	١,٣٢ ±0.05^{ab}	١,٤٤ ±0.06^{ab}
8	١,٨٢ ±0.06^{a}	١,٤٥ ±0.08^{b}	١,٥٥ ±0.09^{b}	١,٦٠ ±0.06^{b}	١,٤٨ ±0.06^{b}	١,٥٠ ±0.06^{b}
10	٢,١٠ ±0.06^{a}	١,٦٥ ±0.05^{b}	١,٧٠ ±0.06^{b}	١,٧٥ ±0.04^{b}	١,٦٠ ±0.09^{b}	١,٦٨ ±0.05^{b}
12	٢,٣١ ±0.06^{a}	١,٧٩ ±0.05^{b}	١,٧٧ ±0.11^{b}	١,٨٤ ±0.05^{b}	١,٧٥ ±0.06^{b}	١,٨٢ ±0.07^{b}
14	٢,٧٠ ±0.07^{a}	١,٩٢ ±0.11^{b}	١,٩٠ ±0.06^{b}	٢,١١ ±0.08^{b}	١,٨٨ ±0.07^{b}	٢,٠٢ ±0.09^{b}
16	٣,١١ ±0.10^{a}	٢,١٨ ±0.14^{b}	٢,١٢ ±0.06^{b}	٢,٢٥ ±0.07^{b}	٢,٠٨ ±0.14^{b}	٢,٢٢ ±0.15^{b}

MS= Mean Square SE= Standerd Error

Means with different letters (a, b) in the same column different significantly at p≤0.05, while those with similar letters are not significant by different.

Table 9. Analysis of variance (ANOVA) for acid value, iodine values, peroxide values and TBA values of sunflower oil during heating periods:

Sv	df		MS								
			0	2	4	6	8	10	12	14	16
Factor	5	Acid value	0.000	0.019	0.029*	0.028*	0.056**	0.046**	0.069**	0.216**	0.323**
		iodine values	0.000	0.068	0.919**	4.361**	2.565**	4.196**	5.433**	6.702**	11.602**
		peroxide values	0.000	0.107*	0.369**	1.201**	2.514**	1.380**	2.627**	2.548**	2.110**
		TBA values	0.000	0.104**	0.011	0.033	0.055*	0.097**	0.137**	0.291**	0.452**
Error	17	Acid value	0.018	0.026	0.027	0.025	0.032	0.030	0.038	0.062	0.075
		iodine values	0.047	0.068	0.134	0.027	0.210	0.264	0.300	0.335	0.439
		peroxide values	0.035	0.048	0.083	0.151	0.206	0.159	0.209	0.206	0.188
		TBA values	0.025	0.047	0.026	0.032	0.038	0.045	0.053	0.074	0.095

Factor = treatment at heating of periods. S.V. = Source of variance. D. f = Degree of freedom. M.S. = Mean of squares. * Significant at P (0.05). ** Highly significant at P (0.01).

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تأثير زيوت بعض النباتات العطرية على درجة الثبات الأكسيدي لزيت دوار الشمس أثناء التسخين

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الملخص

أجريت هذه الدراسة بغرض دراسة تأثير كفاءة إضافة الزيوت العطرية المستخرجة من مصادر طبيعية (الريحان – الكراوية – حصا اللبان – حشيشة الليمون) حيث تم تقدير المواد الفينولية الكلية للزيوت السابقة وتم دراسة الثبات التأكسدى باستخدام جهاز الرانسيمات لزيت دوار الشمس المعامل بمضادات الأكسدة الطبيعية والBHT كمضاد أكسدة صناعى . تمت دراسة عمليات التسخين لمدة ١٦ ساعة على عينات زيت دوار الشمس المعامل بمضاد الأكسدة الطبيعية والصناعية وأظهرت النتائج أن الزيوت العطرية تحتوي على نسبة عالية من الفينول تتراوح من ٥,٦٥ إلى ١٧,٥٦ ملجم / ١٠٠ جرام مقدرة كحامض جاليك على اساس الوزن الجاف.وأيضا احتوي نبات الكراوية على أقل تركيز من المركبات الفينولية الكلية ، في حين كان حصا اللبان والريحان وعشب الليمون أعلى المستويات ،وأظهرت النتائج أن فترة الثبات الأكسيدي والمقدرة بجهاز الرانسيمات لزيت دوار الشمس المعامل سواء بمضاد الأكسدة الصناعى ٢٠٠ جزء فى المليون من (BHT) أو مستخلصات الزيوت العطرية للنباتات محل الدراسة ٤٠٠ جزء فى المليون كانت أطول مقارنة بالعينة الكنترول مع وجود فاعلية أكبر لمستخلصات النباتات العطرية.. بالإضافة إلى ذلك ، أدت إضافة الزيوت النباتية العطرية إلى زيت عباد الشمس إلى تقليل الأكسدة وتحسين ثباتها التأكسدي على مدار ١٦ ساعة من التسخين. لذا تعتبر مستخلصات النباتات العطرية مصدراً هاما وفعالا لمضادات الأكسدة الطبيعية والتي يمكن استخدامها في الزيوت الغذائية بدلا من مضادات الأكسدة الصناعية لما لها من فوائد صحية وغذائية عالية .