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The Effect of Some natural and Synthetic Antioxidants on the Stability of Sunflower Oil During Deep Frying

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ABSTRACT:

Rancidity and deterioration of oils during frying are serious issues that face people worldwide. Scientists are making more efforts to solve or reduce the side effects of this problem by adding natural or synthetic antioxidants to the oil during frying. Antioxidants are organic or synthetic components that help to decrease the oxidation of lipids, and rancidity, and increase the stability of oils during frying. This study aimed to compare the efficiency and safety of natural antioxidants (olive leaves extract and wheat germ extract) to synthetic antioxidants (propyl gallate) to reduce rancidity during frying. In the current study, 200 mg extract of olive leaf, wheat germ, or propyl gallate powder was added to the heated sunflower oil at 180 ◦C for 12 hours (200 mg extract: 1 kg of sunflower oil). Many trials were done to investigate the oil quality as physical properties (color, refractive index, diene, and triene) and chemical analysis (acid value, peroxide value, saponification number, iodine number, benzidine value, and thiobarbituric acid content). In addition, the capacity of antioxidants to hunt the reactive oxygen species was measured by antioxidant assays. Also, the content of total phenols and total flavonoids was calculated in these extracts. Generally, the physicochemical properties and chemical analysis of heated oil with antioxidants significantly maintained the quality of oils during deep-frying. The efficiency of antioxidants was arranged as follows: Olive leaves extract >wheat germ extract >propyl gallate, and the best frying period was at 4 hours.

Keywords: *Olive leaves, Wheat germ, Deep-frying, Antioxidants*

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1. INTRODUCTION

The process of frying is considered one of the most famous cooking methods, and it is used to change the food quality and excess its shelf life (1). Additionally, frying gives the food a pleasant taste, golden color, and delicious flavor (2). The popularity of deep-frying has grown in every home kitchen, and especially in restaurants that serve junk foods because of the delicious sensory characteristics of fried foods, low cost, and an increasing purchase of instant ready foods (3). Fast food restaurants and street vendors frequently reuse cooked oil to reduce the price of fried products. This cooked method usually changes the physical and chemical properties of fried oil and causes

the production of hazard products, which increases the risk of different diseases such as cancer, hyperlipidemia, injury of liver, and coronary heart diseases (4). Food scientists make the best effort to reduce the generation of unacceptable elements in frying oil by many techniques such as selecting low-unsaturated oil for frying (5) and adding effective antioxidants to frying oil (6). The addition of synthetic antioxidants such as propyl gallate (PG), tert-butyl hydroquinone (TBHQ), butylated hydroxy anisole (BHA), and butylated hydroxytoluene (BHT) to the frying oils are considered the effective method and regularly used way. This process prolongs the storage of oils, protects the oil deterioration at room temperature, and enhances the oxidative stability of frying oils compared with natural antioxidants (7,8). However, these antioxidants have poor defense opposed to thermo-oxidative deterioration under deep frying conditions because of their thermal decomposition, steam distillation, and absorption by fried products (9). Also, the perceived hazard effects of artificial antioxidants on health restrict their use in the food industry. For a long time, many scientific articles confirmed the ability of antioxidants from natural sources to decrease the oxidation of frying oils and exhibited greater efficiency than some artificial antioxidants on sometimes. Plant extract is a good example of natural antioxidants; it contains various bioactive compounds, especially phenolic compounds, phytosterols, tocopherols, and carotenoids that can inhibit the thermo-oxidative deterioration of frying oil and the presence of toxic components like acrylamide and heterocyclic amines (6,10). In that case, olive leaves are a good example of natural antioxidants, which contain a high number of phenolic compounds. Olive leaves have the highest antioxidant and scavenging power among the different parts of the olive tree. Oleuropein is the principle phenolic element in olive leaves, but there are others like hydroxytyrosol, luteolin, tyrosol, apigenin, verbascoside, caffeic acid, rutin, quercetin, chlorogenic acid, epicatechin (11, 12, 13). Additionally, the content of oleuropein in olive oil ranges between 0.005- 0.12%, and Alperujo reaches up to 0.87%, while the content of both compounds recorded 1% and 14% in olive leaves, respectively (14). Wheat germ is considered another example of an excellent natural antioxidant. Wheat germ is a valuable by-product resulting from cereals during the milling process. This germ is the part from three parts that form a single whole fruit of wheat “caryopsis”; these parts are endosperm, bran, and germ, which record (80-84%), (14-15%), and (2-3%), respectively. This wheat germ is rich in oil content, which varies from 10-15% depending on the type of wheat, kind of solvent, how to extract, and degree of purification. The crude wheat germ oil is yellow dark and has a strength odor. Before any use of wheat germ oil must be removed the undesirable flavor and odor that varies from type to type. Addition to, undesirable strange particles must be taken away without losing other nutritional components (15). Also, wheat germ oil contains a highly significant number of policosanols (16) phytosterols (17), tocopherols, carotenoids (18), thiamin, riboflavin, flavonoids, sterols, octacosanols, glutathione, Steryl ferulates (19), and numerous enzymes (20). Therefore, the present study aimed to study the role of natural antioxidants extracted from olive leaves and wheat germ on decreasing the deterioration and oxidative of sunflower oil during deep-frying method at different hours compared with propyl gallate as a synthetic antioxidant.

2. Materials and Methods

Materials

The wheat germ was obtained from the North Cairo Flour Milling Company. While olive leaves (*Olea europaea,* L.) were taken from the Agriculture Researcher Center, Giza, Egypt. The refined sunflower oil was purchased from Masara Al-Huda, Al-Mahalla

Al-Kubra, El-Gharbia Governorate, and the fresh potato was bought from the domestic market at Shebin El-Kom, Menoufia Governorate, Egypt.

Reagents

Methanol, ethanol, acetone, and glacial acetic acid were purchased from Al-Gomhoria Company for Trading Drugs, Chemical and Medical Instruments, Tanta, El-Gharbeia governorate, Egypt. Iodine, potassium iodine, potassium hydroxide, phenolphthalein, N octane, brome, sodium thiosulfate, potassium dichromate, Thiobarbituric acid, ferric chloride, sodium nitrite, sodium hydroxide, and sodium carbonate were purchased from El-Nasr Company for Intermediate Chemicals, Giza, Cairo, Egypt. DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt), potassium persulfate, Trolox, gallic acid, catechin, propyl gallate, Folin–Ciocalteu, 2,4,6-Tris(2-pyridyl)-s-triazine were purchased from Sigma-Aldrich, St. Louis, MO, USA.

Methods

Preparation and extraction of wheat germ oil

In the beginning, the wheat germ was ground into a fine powder using an electrical mill (Braun, Type 4294, Germany), then extraction was carried out using a glass Soxhlet extractor at 40 ^{0}C for 6 hours (10-gram sample and 200 milliliters petroleum ether). The crude ether extract was dried by a vacuum rotary evaporator (Buchi, Buchi 011, Switzerland). This method was repeated more than one time until the required quantity was reached. To assess the activity of wheat germ as an antioxidant, redissolved the crude extract in ethanol to a concentration of 1 % (w/v) (21).

Preparation and extraction of olive leaves

Olive leaves (*Olea europaea*, L.) were dehydrated in a vacuum drying oven (vacuum oven, Zhicheng, Model ZKD-5055, China) at 40 ^{0}C for 1 hour and crushed into soft particles by an electrical grinder (Braun, Type 4294, Germany) and sift into 80 mesh sieves (British standard screen). The soft particles were reserved in a plastic bag in the freezer and stored at -20ºC until used (Deep freezer, Haier, Model HF-255FAA, Malaysia). Ethanolic extract was prepared by mixing 100 milliliters of ethyl alcohol to 10 grams of olive leaves (*Olea europaea*, L.). This blend was Shaked for 24 hours, then the mixture was centrifuged at 10000 rpm for fifteen minutes (Hermle, Model Z366K, Germany), and the supernatant was filtrated by Watman No 41. The supernatant was dried using a vacuum rotary evaporator (Buchi, Buchi 011, Switzerland). This method was repeated more than one time until the required quantity was reached. The crude extract was redissolved in ethanol to a concentration of 1 % and assayed for antioxidant activity.

Determination of total phenols

Total phenols content was determined calorimetrically (T80 U.V/Visible spectrometer/instruments Ltd) by the Folin-Ciocalteu method (22).

Determination of total flavonoids

The content of total flavonoids of crude extracts was determined colorimetrically (T80 U.V/Visible spectrometer/ instruments Ltd) by the method according to (23).

Identification of phenolic compounds by HPLC

The preparation of olive leaves sample to identify the phenolic compounds by HPLC was carried out according to the following steps: Accurate weight of dehydrated sample of oil leaves was taken, then sample was soaked in 25 ml distilled water and left on shaker for one day at 200 rpm. The mixture was filtered by filtration paper (Whatman, No. 3 mm) under vacuum and centrifuged under cooling at 8000 rpm for thirty minutes (Refrigerated Centrifuge, Centurion Scientific, Model

K241R, United Kingdom). The acidity of extract must be adjusted to pH 2.5 by Orthophosphoric acid. The acidic extracted sample was divided into three equal parts with the same volume of Ether. The three parts of Ether layer were collected together and evaporated to dryness under pressure at 30ºC. The resulting residue was redissolved in 3 ml of HPLC methanol and filtered through a 0.2 mm filter before injection by HPLC instrument.

Each phenolic compound of olive leaves extract were identified separately by a Hewlett-Packard HPLC (Model 1100), the separation method of phenolic compounds can be identified in the following steps: column, hypersil C18 with 5 mm; injection, rheodyne valve (Model 7125); flow rate, 1 ml/min; mobile phases: two mobile phases, 0.5 % (v/v) ethanoic acid at pH 2.65 (A), 0.5 % (v/v) ethanoic acid in 99.5 % (v/v) acetonitrile (B); detector, ultraviolet detector at 254 nm; separation time, 35 min beginning with mobile phase (A) and finishing by mobile phase (B). The identification of phenolic compounds was done by comparing the retention times between the sample and the standard of phenolic compounds chromatogram (24).

Antioxidant activity

DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity

The ability of extracts (olive leaves, wheat germ), and propyl gallate powder as antioxidants was determined according to the method by (25).

ABTS (2,2-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt) radical scavenging activity

The ABTS•+ assay is another analysis that was used for measurement the activity of extracts of olive leaves, wheat germ, and propyl gallate powder as antioxidants. This test was carried out according to (26).

Ferric reducing antioxidant power (FRAP)

To investigate the power of extracts (olive leaves, wheat germ), and propyl gallate powder to scavenge the react oxygen species, the Ferric Reducing Antioxidant Power (FRAP) was used according to the procedure described by (27).

Frying process

Fresh potato samples were fried in sunflower oil at 185 $\pm$ 5 ^{0}C on laboratory conditions as detailed by (28) as follows: 350 gm of fresh potato cut into slices (the height and width of potato slice about 40-50×10 mm, respectively) and fried in a Tefal pan with four liters of sunflower oil. Sunflower oil was heated to 185$\pm$5 ^{0}C then slices of potato were immersed in oil and fried almost for ten minutes. This process continued for 12 hours, and the oil was left to cool, three times, at room temperature after 4 hours of deep-frying. After each cooling, 100 ml of sunflower oil was kept in a clean glass and stored in the freezer at –20^{0}C until analysis.

The antioxidants were added to the sunflower oil during frying as follows:

200 mg/kg oil crude extract of olive oil leaves or wheat germ oil or 200 mg/kg oil of Propyl gallate.

Physical properties of sunflower oil

Refractive index

A refractometer (Carl Zeis JENA GBR) was used to measure the refractive index of oil samples at 25^{0}C according to the procedure (29).

Color

Color was measured according to the procedure described by (30). The color absorbance of the oil samples was measured at 450 nm (T80 U.V/Visible spectrometer/instruments Ltd) in 1% chloroform solution.

Conjugated diene and conjugated triene

The absorbance of Diene and Triene of the oil samples was measured at 234 nm and 270 nm in 1% oil solution in octane, respectively. This procedure was carried out according to (30).

Fat constants

Acid value (mg KOH / gm oil), peroxide value (meq of oxygen peroxide/kg oil), iodine number (gm iodine/100 gm oil), and saponification value (mg KOH / 1 gm oil) were determined according to described by (21).

Determination of the benzidine value

Benzidine value was measured colorimetrically (T80 U.V/ Visible spectrometer/ instruments Ltd) as described by (30).

Determination of the Thiobarbituric acid value

Thiobarbituric acid (TBA) was determined colorimetrically (T80 U.V/Visible spectrometer/instruments Ltd) as described by (31).

Fatty acids profile of sunflower oil

Individual fatty acids were determined by gas chromatography (GC-4CM Shimadzu) according to the methods mentioned by (32).

Statistical analysis

The results were recorded as Means (M) ± Standard Deviation (SD) and analyzed using a completely randomized factorial design (33). When the main effects were detected as significantly at P ≤ 0.05, the means of treatments (frying hours and antioxidants) were separated by the Least Significant Differences (LSD) test. The differences between treatments (frying hours and antioxidants) at P ≤ 0.05 were considered significant.

3. Results And Discussion

Olive leaves extract contains many bioactive compounds such as total phenols and total flavonoids, both are the major components of the nonenzymatic antioxidant defence system. These compounds can scavenge and protect the body against increasing reactive oxygen species (ROS). Results in Table 1. show that the average total phenols for olive leaves extract and wheat germ extract were 94.247±1.812 and 6.760±0.348 (mg gallic acid/g sample), respectively. In addition, the content of total flavonoids was twice higher in olive leaves extract than in wheat germ extract. Furthermore, the efficiency of DPPH was 300.069±0.157 g Trolox/g sample (93.624 %) in olive leaves extract and 64.903±1.856 g Trolox/g sample (27.099 %) in wheat germ extract. According to the results in Table 1. the same previous trend was noticed among olive leaves extract and wheat germ extract in ABTS and FRAP, which recorded 2.288±0.009 and 0.196±0.001 in ABTS, 2.251±0.017 and 0.114±0.003 in FRAP, respectively.

Table (1). The content of total phenols, total flavonoids, and the antioxidant activity assays (ABTS, DPPH radical scavenging activity, and free radical reducing power, FRAP) in extracts of wheat germ and olive leaves.

Parameters	Olive leaves	Wheat germ
	Mean±SD	Mean±SD
Total Phenols (mg gallic acid/g sample)	94.24±1.81	6.760±0.35
Total Flavonoids (mg ccatechin /g sample)	4.568±0.10	0.175±0.02
DPPH (%)	93.62±0.06	27.09±1.44
DPPH (mg Trolox/g sample)	300.1±0.15	64.90±1.85
ABTS (g Trolox/g sample)	2.288±0.01	0.196±0.00
FRAP (g Trolox/g sample)	2.251±0.02	0.114±0.00

Each value represents the Mean ± SD of three replicates.

Generally, results in Table 1. illustrated that the extract of olive leaves had the most efficiency than wheat germ extract in all tested parameters, including total phenols, total flavonoids, and antioxidant activity assays. The same results were confirmed by (34), who found that the content of total flavonoids was smaller than total phenols in olive leaf extract taken from olive trees grown in El-Farafra and Borg El Arab. Many researchers determined the efficiency of olive leaves extract as an antioxidant by different methods (DPPH, ABTS, and FRAP) and found that olive leaves extract is a good source of

antioxidants and plays an excellent role in protecting our bodies from chronic diseases such as cancer, atherosclerosis, rheumatoid arthritis, inflammation, and aging (35, 36).

The amount and number of phenolic fractions of olive leaves extract were identified by HPLC and were recorded in Table 2. *p*-hydroxybenzoic acid, Quercetin, and Ortho coumaric acid were considered the main compounds in olive leaves extract. Values of these fractions were 340.5, 331.3, and 220.2 mg/100g, respectively. On the other hand, Chlorogenic acid, Syringic acid, and para coumaric acid were recorded as the lowest values between phenol composition fractions. Six phenolic fractions were determined at less than 10 mg/100g. These fractions were arranged from the lowest value to the highest value as follows: Chlorogenic acid > Syringic acid> Para coumaric acid> Salicylic acid > Protocatechuic acid > Gallic acid. Generally, the highest concentration of phenolic fraction compounds was observed for P-hydroxybenzoic acid, and the lowest was Chlorogenic acid. These results differed from (37), who found that the extracts from olive leaves were rich in bioactive compounds, including phenolic acids, flavonoid aglycones, flavonoid mono-glycosides, flavonoid di-glycosides, and seco-iridoids. The main phenolic compounds in the previous study were Caffeic acid, Dihydro-caffeic acid, and Quinic acid. Most of the studies on olive leaves extracts differed in the main phenolic compounds. These differences are due to the geographical location, type of cultivar, collection time (38) extraction time, temperature, solvent-to-substrate ratio, polarity of solvent, and degree of pH (39). In addition, it is very important to observe that plant extracts like olive leaves are very complex in composition, and the determination & identification of each phenolic compounds requires new and more accurate analytical methods.

Changes in the color of oils from golden yellow to brown or dark brown during deep frying are positively correlated to the quality of frying oil and oxidative deterioration. Results of the relative changes in the color during frying in sunflower oil with different antioxidants are illustrated in Figure 1A. Non-significant ($p>0.05$) differences were observed between the effect of antioxidants on change of color during the frying process in sunflower oil, all of them have the same effect at the different frying hours. On the other hand, frying hours showed the opposite trend, which was significant ($P\leq0.05$). These results are in the agreement with those reported by (40,41). The color change during frying results from the accumulation of non-volatile deterioration elements like oxidized triacylglycerols and free fatty acids, which are formed because of chemical reactions such as oxidation, polymerization, etc. (42).

Table (2). Identification of the phenolic compounds profile in the olive leaves extract by HPLC.

Phenolic fraction compound	Olive leaves extract (mg/100 g dry weight)
Gallic acid	3.88
Protocatechuic acid	3.03
Catechin	9.20
P-hydroxybenzoic acid	340.5
Para coumaric acid	2.03
Vanillic acid	139.3
Caffeic acid	11.87
Syringic acid	1.35
Ferulic acid	6.93
Rutin	30.6
Ortho coumaric acid	220.2
Salicylic acid	2.32
Chlorogenic acid	1.02
Quercetin	331.3

The refractive index is a beneficial scientific index to determine the degree of oil unsaturation, if the number of conjugated double bonds in the oil increases, the value of refractive index will increase (43). The relative changes in the refractive index (RI) during frying in sunflower oil with natural and synthetic antioxidants are shown in Figure 1B. From the results listed in the previous figure,

we conclude that there were non-significant differences (P>0.05) between the values of PG, WG, and OL in the refractive index. Hence, all antioxidants exhibited the same effect when added to the sunflower frying oil, which was heated for 12 hr. Despite the results being almost equal at different heating periods, the refractive index of the oil showed significant differences (P≤ 0.05) between them. Many studies indicated that the RI could be affected by many factors, including the degree of saturation, the percentage of linoleic acid content, and the degree of polymerization that takes place in oils during frying (44). In other studies, the same results were observed by (45,46).

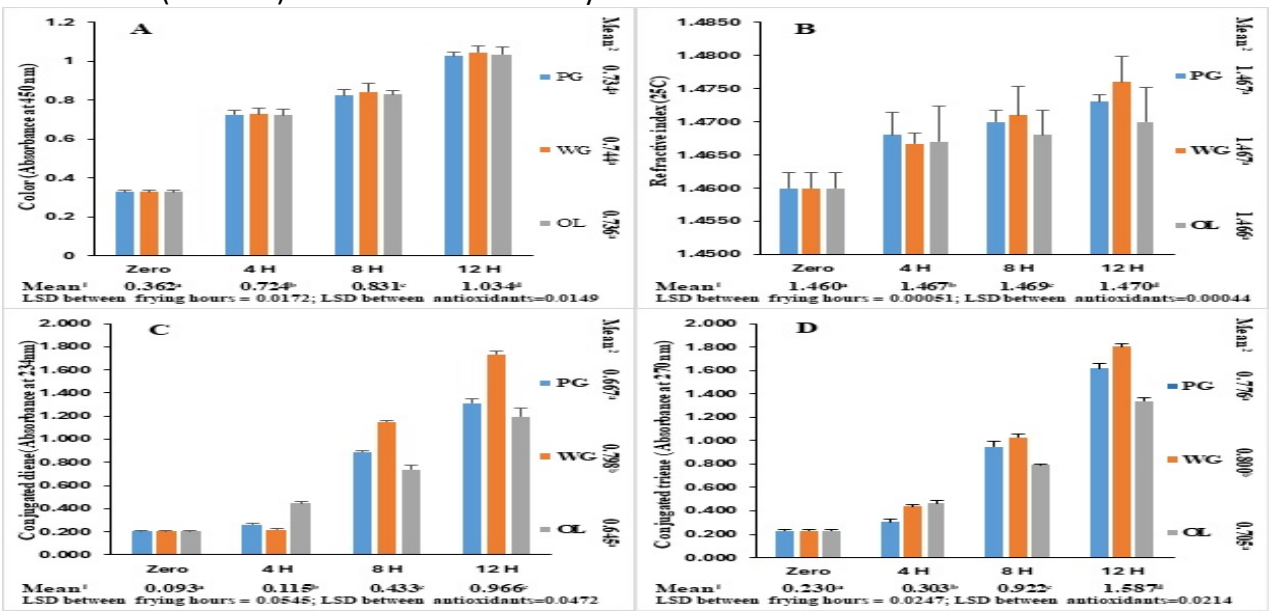

Figure (1). Changes in color, refractive index, diene, and triene during frying in sunflower oil with different antioxidants.

Conjugated dienes and trienes are good chemical tests to determine the increase in the oxidation rate of heated oils. The changes in diene are associated with the generation of primary oxidation products. Meanwhile, the triene content is used to determine the parameters of fat oxidation depending on oxidation conditions (42, 47). The relative changes in the diene and triene during frying in sunflower oil with natural and synthetic antioxidants are shown in Figure 1C&D. From the results in the previous table, we conclude that there were no significant differences (P>0.05) between the values of PG and OL in the diene and triene. Hence, both antioxidants exhibited the same effect on inhibiting the change in conjugated diene and trienes during deep frying sunflower oil for 12 hr. compared with wheat germ oil. On the other hand, we can observe the positive correlation between the increase of diene and triene values and the increase in frying periods. This increase is possible result from the decay of ketones by oxidation. Also, (48,49) reported the same results, they studied the effect of rosemary as a natural antioxidant on deep-frying oil and found that rosmarinic acid had an excellent inhibitory result to prevent the accumulation of conjugated diene pending deep frying while its triene had a moving down trend at the end of fourth day due to the decay of ketones. In another study, the researchers noticed a positive correlation between a reduction in conjugated diene, polar content, and a rise in the quality of oil by increasing the oxidative stability after twenty hours of deep-frying at 160 °C (50).

Acid value and free fatty acids are considered sensitive indicators for the hydrolysis of

triglycerides and oxidative decomposition of hydroperoxides in fats and oils during storage, processing, and frying (51). Results about the effect of different antioxidants (WG, OL, PG) and different frying periods (4, 8, 12 hr.) on acid value are presented in Figure 2A. According to the previous table, the addition of different antioxidants maintained the acid value almost stable at 4 hours compared with the control sample. After that, the acid value was increased gradually depending on the increase in frying periods, the type of antioxidant, and its properties. The activity of antioxidants in the reduction of acid value of the samples was in the following order: OL > PG >WG, which were significant ($P \leq 0.05$) different from each other. On the other hand, the best frying periods were noticed at zero hours and 4 hours, meanwhile, non-significant differences ($p>0.05$) were recorded between 4 and 8 frying hours. These results were in line with (48,52).

Data in Figure 2B. shows the effect of different antioxidants on the peroxide value (PV) during sunflower frying oil at different hours. From such data, it could be noticed that all antioxidants showed significant ($p\leq0.05$) differences between them in peroxide value; the olive leaves had the best activity in the reduction of the peroxide value, which recorded 9.724 mg/100 g oil compared with other antioxidants. The high efficiency of olive leaves in the reduction of the peroxide value resulted from their high content of total phenols. The obtained data from the previous figure indicated that the peroxide value increased significantly ($p\leq0.05$) with the heating time. After four hours, all antioxidants showed approximately the same peroxide value of propyl gallate, wheat germ, and olive leaves, which recorded 10.32, 11.71, and 9.724 mg/100 g oil, respectively. In addition, the results of propyl gallate and olive leaves were similar after eight hours of the frying process, but wheat germ recorded a higher peroxide value (16.3 mg/100 g oil) than other antioxidants. The same previous trend between antioxidants was observed after 12 hours of the frying periods. Finally, the best antioxidants in reducing the peroxide value were olive leaves, propyl gallate, and wheat germ respectively while the best frying period was recorded at four hours. Similar results were also, reported by (53,54).

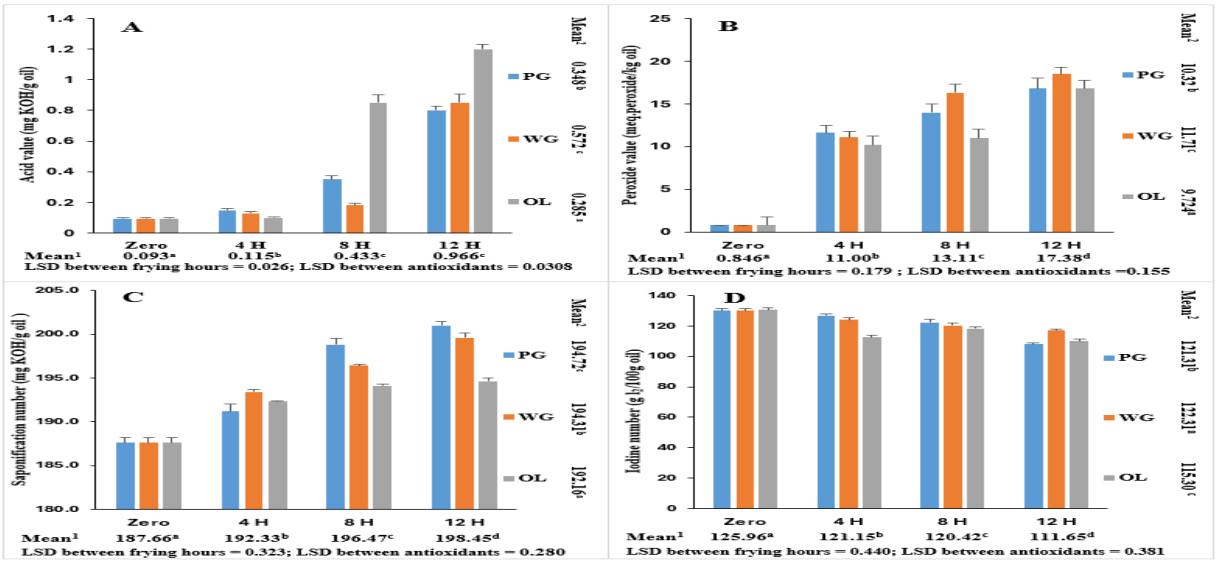

Figure (2). Changes in fat constants (acid value, peroxide value, saponification number, and iodine number) during frying in sunflower oil with different antioxidants.

The saponification number is used to determine the quantity of free fatty acids or fat/lipids that react with an alkaloid solution. For this reason, the results of saponification

number and acid value are very similar. According to the data in Figure 2C, it can be noted that all antioxidants exhibited significant differences ($p \leq 0.05$) among themselves in the value of saponification number. In addition, the value of the saponification number increased significantly ($P \leq 0.05$) with heating time. After four hours, PG showed the lowest value compared to other antioxidants, followed by olive leaves extract, and wheat germ, which recorded 191.2, 192.3, and 193.4 mg/100 grams of oil, respectively. The activity of PG is very highly effective at medium and low temperatures in the initial frying hours. After that, the loss efficiency of synthetic antioxidants at the beginning of deep-frying under different conditions is very quick, then the activity is relatively low at high temperatures over 180 ^{0}C for a long time (55). At the end of the two frying periods (8 and 12 hours), olive leaves had the best activity in reducing the value of saponification number, which recorded 194.1 and 195 mg/100 grams of oil compared to other antioxidants, respectively. The high efficiency of olive leaves in reducing the value of saponification number resulted from their high content of total phenols. Finally, the best antioxidants in reducing the value of saponification number were olive leaf, wheat germ, and propyl gallate, respectively, while the best frying time was recorded at four hours. These results are in agreement with (47), who studied the effect of butylated hydroxyanisole, *Lepidium sativum,* and *Aframomum corrorima* as antioxidants on the stability of fried palm oil for six days.

The low values of saponification number were arranged as follows: butylated hydroxyanisole> *Lepidium sativum*> *Aframomum corrorima* seeds extracts, which recorded 162.5, 169.67, and 173.03 after six days, respectively.

The iodine number (IN) is a good indicator to determine the degree of unsaturation of oils. These differences in iodine number may be due to the different content of the poly unsaturated fatty acids (44). The relative changes in the iodine number (IN) during frying in sunflower oil with natural and synthetic antioxidants are shown in Figure 2D. In general, all samples showed decreasing iodine number during the frying hours (zero,4,8, and 12) of heated sunflower oil with natural and synthetic antioxidants. However, we found that the antioxidants were added to the sunflower oil tried to maintain its stability as much as possible. All antioxidants added to the heated sunflower oil showed significant differences between them in the iodine number ($P \leq 0.05$). Wheat germ, propyl gallate, and olive leaf exhibited high effect in maintaining the oil stability from the formation of polymer and transformation of conjugated double bonds to saturated bonds during frying, respectively. In another way, the heated sunflower oil samples in different periods (zero,4,8, and 12) showed significant differences between them in the iodine number ($P \leq 0.05$). The best trend of frying periods was in the following order: zero < 4 hr. < 8 hr. < 12 hr. Similar results were also reported by (56; 57; 58).

The Thiobarbituric acid (TBA) test is used to measure a toxic compound (malondialdehyde) resulting from deep-frying. For this reason, it is used as an indicator for measuring the stability degree of any oil safe to eat. The Thiobarbituric acid test is related to the malondialdehyde content, which was formed during the oxidation of lipids (59). Malondialdehyde is the most common aldehyde product of the secondary oxidation of oil, which is produced from the decay of hydroperoxides during the oxidation of lipids in foods (46). The relative changes in the Thiobarbituric acid (TBA) during frying in sunflower oil with natural and synthetic antioxidants are shown in Figure 3A. The minimum TBA value was observed after frying for 12 hours, which recorded 0.372, 0.360, and

0.245 mg/100 grams for propyl gallate, wheat germ, and olive leaves, respectively. In general, the antioxidants of olive leaves in inhibiting sunflower oil were superior to the antioxidants of wheat germ and PG. The reason for this efficiency is that olive leaf extract had the ability to retard the oxidation of lipids by donating hydrogen to free radicals and protecting them as stable at elevated temperatures (52). Similar results were also reported by (60), who noticed that the formation of lipid peroxides was significant ($p<0.05$) decreasing with increasing the addition of phenolic extracts from olive leaves to soybean oil.

The benzidine value method is similar to the Thiobarbituric acid (TBA) test used for evaluating the secondary oxidized fat products, including alcohols, carboxylic acids, aldehydes, and ketones that result from the oxidation of lipids (61). Data in Figure 3B show the effect of different antioxidants on the benzidine value (BV) during frying in sunflower oil at different hours. It can be noted that all antioxidants showed significant differences ($p\leq0.05$) among themselves in the values of benzidine value. At the end of frying time, olive leaves had the best activity in reducing the value of benzidine, which recorded 1.422 mg/100 grams of oil compared to other antioxidants. The high efficiency of olive leaves in reducing the benzidine value resulted from their high content of total phenols. The data obtained from the previous figure indicated that the value of benzidine increased significantly ($P\leq0.05$) with heating time, which was recorded at 0.0053, 0.1026, 0.3773, and 0.7785 at zero,4,8, and 12 frying hours, respectively. Finally, the best antioxidants in reducing the value of benzidine were olive leaf, propyl gallate, and wheat germ, respectively, while the best frying time was recorded as four hours. These results are in agreement with (47), who studied the effect of butylated hydroxyanisole, *Lepidium sativum,* and *Aframomum corrorima* as antioxidants on the stability of fried palm oil for six days. The low values of anisidine value were arranged as follows: butylated hydroxyanisole> *Lepidium sativum*> *Aframomum corrorima* seeds extracts, which recorded 16.47, 20.36, and 36.39 after six days, respectively.

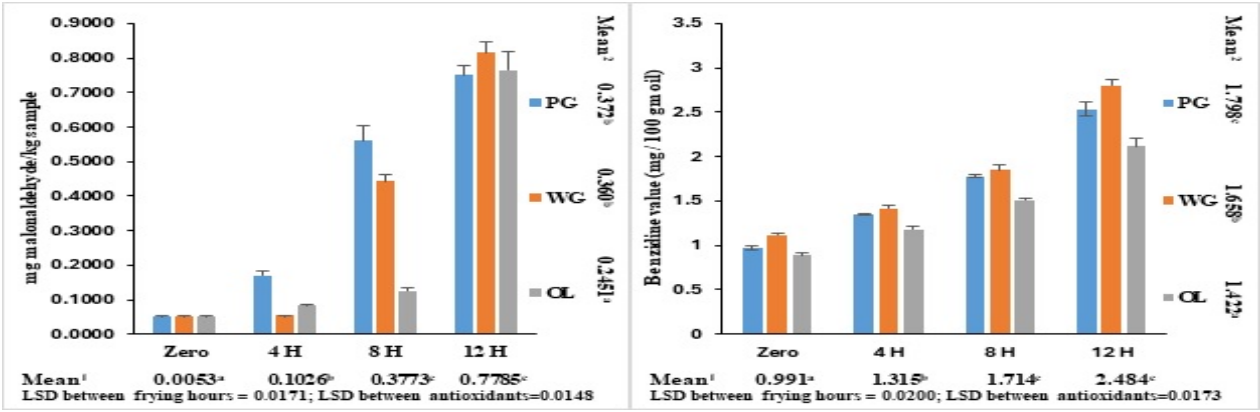

Figure (3). Changes in malonaldehyde (MDA) and benzidine value (BV) during frying in sunflower oil with different antioxidants.

The data presented in Table (3) shows the effect of different antioxidants on the fatty acid composition during frying with sunflower oil at different hours. After 4 hours, the Monounsaturated fatty acids (MUFA)of propyl gallate showed the lowest value compared to other antioxidants, followed by wheat germ and then olive leaves extract, which recorded 23.5, 23.7, and 24.88 mg/100 grams of oil, respectively. The same previous trend was observed among antioxidants at the frying period of 8 hours. At the end of the

frying period, propyl gallate and wheat germ had the same activity, recording 23.25 mg/100 grams of oil, compared to olive leaves extract. increasing frying time,12 hours, Polyunsaturated fatty acids (PUFA)of wheat germ extract showed the lowest value compared to other antioxidants, followed by propyl gallate and, olive leaves then which recorded 61.54, 61.99, and 62.49 mg/100 grams of oil, respectively.in addition, the Saturated fatty acids (SFA) at 12 h of wheat germ extract showed a higher value compared to other antioxidants, followed by propyl gallate and olive leaves then, which recorded 15.21, 14.76, and 13.52 mg/100 grams of oil, respectively. It was found the lowest values at 12h recorded for palmitoleic acid were olive leaves extract, PG, and wheat germ (0.2,0.14 and 0.17), respectively. it was found at 12h The lowest values recorded for linolenic acid were (0.14, 0.14, and 0.18) which were recorded for PG, wheat germ, and olive leaves extract, respectively. While the high values of fatty acids were noticed between linoleic acid and oleic acid, which were recoded 63.24 & 24.63, 62.95 & 23.52, and 62.89 & 23.33 for propyl gallate, wheat germ, and olive leaves extract, after deep frying of sunflower oil for 4 hours, respectively. The results were consistent with the previous studies by (48,53,62,63).

Table (3). The relative changes in fatty acids composition during frying in sunflower oil with different antioxidants.

Fatty Acids	Zero	Gallate propyl			Wheat germ			Olive leaves		
		4	8	12	4	8	12	4	8	12
Myristic acid (C14:0)										
Palmitic acid (C16:0)	6.9	8.65	9.02	9.32	8.7	9.82	10.53	8.05	8.33	8.79
Stearic acid (C18:0)	3.79	4.07	4.35	4.88	4.16	4.29	4.32	3.61	4.3	4.35
Arachidic acid (C20:0)	0.25	0.31	0.53	0.56	0.27	0.31	0.36	0.28	0.3	0.38
Palmitoleic acid (16:1Δ9)	0.28	0.17	0.15	0.14	0.18	0.17	0.17	0.25	0.22	0.2
Oleic acid (C18:1Δ9)	24.98	23.33	23.18	23.11	23.52	23.42	23.08	24.63	24.03	23.79
Linoleic acid (C18:2Δ9,12)	63.5	63.24	62.59	61.85	62.95	61.82	61.4	62.89	62.6	62.31
α- Linolenic acid (C18:3Δ9,12,15)	0.3	0.23	0.18	0.14	0.22	0.17	0.14	0.29	0.22	0.18
Gadoleic acid (C20:1Δ11)										
a SFA	10.94	13.03	13.9	14.76	13.13	14.42	15.21	11.94	12.93	13.52
b MUFA	25.26	23.5	23.33	23.25	23.7	23.59	23.25	24.88	24.25	23.99
c PUFA	63.8	63.47	62.77	61.99	63.17	61.99	61.54	63.18	62.82	62.49
Unsaturated/ Saturated	8.14	6.67	6.19	5.78	6.62	5.93	5.57	7.38	6.73	6.40

a SFA, Saturated fatty acids.
b MUFA, Monounsaturated fatty acids.
c PUFA, Poly unsaturated fatty acids.
1Mean in the same row with different letters are significantly different ($p \leq 0.05$).
2Mean in the same column with different letters are significantly different ($p \leq 0.05$).
LSD=Least Significant Difference, PG= Propyl gallate, WG= Wheat germ, OL= Olive leaves.

4. Conclusion

The oxidation stability of oils during deep-frying is an important issue that faces people worldwide. In this study, adding olive leaves extract to sunflower oil and frying for 12 hours significantly improved oil quality throughout the different periods. These results were confirmed by different methods such as the physical and chemical parameters, fatty acids profile, and determination of the oil toxicity by measuring benzidine value and thiobarbituric acid value. Additionally, the olive leaf extract was more active than wheat germ extract and propyl gallate in delaying the formation of hydrogen peroxide. The efficiency of olive leaf extract may be due to the high content of

polyphenols and polyflavonoids. This efficiency was confirmed by different antioxidant assays as DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity, ABTS (2,2-Azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) diammonium salt) radical scavenging activity, and Ferric reducing antioxidant power. Finally, we need more studies about the efficiency and safety of plant extracts, which are used to retard the degradation and oxidation of oil during deep-frying.

Conflict of Interest

The authors declare that there is no conflict of interest.

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5. References.

1. Hosseini H, Ghorbani M, Meshginfar G, Mahoonak,A.A review on frying: Procedure, fat, deterioration progress and health hazards. *J. Am. Oil. Chem. Soc. 2016*; 93:445–466. https://doi.org/10.1007/s11746-016-2791-z
2. Yu K, Cho H, Hwang K. Physicochemical properties and oxidative stability of frying oils during repeated frying of potato chips. *Food science and biotechnology*.2018; *27*(3):651-659. https://doi.org/10.1007/s10068-017-0292-y.
3. Rahimi J, Adewale P, Ngadi M, Agyare K, Koehler B. Changes in the textural and thermal properties of batter coated fried potato strips during post frying holding. *Food and Bioproducts Processing*. 2017; 102:136–143. https://doi.org/10.1016/j.fbp.2016.12.013
4. Gadiraju T, Patel Y, Gaziano J, Djoussé L. Fried food consumption and cardiovascular health: A review of current evidence. *Nutrients* 2015; 7(10):8424–8430. https://doi:10.3390/nu7105404.
5. Molina-Garcia L, Santos C, Cunha S, Casal S, Fernandes J. Comparative fingerprint changes of toxic volatiles in low PUFA vegetable oils under deep-frying. *J. Am. Oil. Chem. Soc*. 2017; 94(2):271–284. https://doi.10.1007/s11746-016-2943-1.
6. Urban˘ci˘c, S., Kolar M, Dimitrijevi´ D, Dem˘sar L, Vidrih R. Stabilization of sunflower oil and reduction of acrylamide formation of potato with rosemary extract during deep-fat frying. *LWT-Food Science and Technology*.2014; 57(2): 671–678. https://doi.org/10.1016/j.lwt.2013.11.002
7. Maskan ME, Horuz, ER. Evaluation of antioxidant properties of Za'atar (*Thymbra spicata*) essential oils as a natural antioxidant for the stability of palm olein during the deep-fat frying process. *Journal of Food Science & Technology* .2017;54(7):1794-1801. http://doi.10.1007/s13197-017-2608-6.
8. Zhao X, Wu S, Gong G, Li G, Zhuang L. TBHQ and peanut skin inhibit accumulation of PAHs and oxygenated PAHs in peanuts during frying. *Food Control*.2017; 75:99-107. http://doi.10.1016/j.foodcont.2016.12.029
9. Aladedunye F, Przybylski R, Matthaus B. Performance of antioxidative compounds under frying conditions: A review. *Crit. Rev. Food Sci. Nutr.* 2017;57(8):1539-1561. http://doi.10.1080/10408398.2013.777686.
10. Cheng Ka, Wu Q, Zheng Z, Peng X, Simon J, Chen F, Wang M. Inhibitory effect of fruit extracts on the formation of heterocyclic amines. *J. Agric. Food Chem.* 2007; 55:10359–10365 10359. http://doi10.1021/jf071820zCCC: $37.00
11. Martín-Vertedor D, Garrido M, Pariente J, Espino J, Delgado-Adámez J. Bioavailability of bioactive molecules from olive leaf extracts and its functional value. *Phytotherapy Res*. 2016; 30:1172–1179. http://doi.10.1002/ptr.5625.

12. Magrone T, Spagnoletta A, Salvatore R, Magrone M, Dentamaro F, Russo M, Jirillo E. Olive leaf extracts act as modulators of the human immune response. *Endocrine, Metabolic & Immune Disorders-Drug Targets.* 2018;18(1):85-93. http://doi.10.2174/1871530317666171116110537.

13. Nath P, Majumder D, Debnath R, Debnath M, Sekhawat S, Maiti D. Immunotherapeutic potential of ethanolic olive leaves extract (EOLE) and IL-28B combination therapy in ENU induced animal model of leukemia.*Cytokine*. 2022; 156:1-13. http://doi.10.1016/j.cyto.2022.155913.

14. Japón-Lujan R, Luque de Castro M . Small branches of olive tree: a source of biophenols complementary to olive leaves. J. Agric. *Food Chem.*2007;55(11):4584-8. http://doi:10.1021/jf070215t.

15. Wang C, Johnson L. Functional properties of hydrothermally cooked soy protein products. *J. Am. Oil. Chem. Soc.* 2001; 28(2):189-195. https://doi.org/10.1007/s11746-001-0242-y.

16. Irmak S, Dunford N, Milligan J. Policosanol contents of beeswax, sugar cane and wheat extracts. *Food chemistry*.2006; 95(2):312-318. https://doi.org/10.1016/j.foodchem.2005.01.009

17. Nyström L, Paasonen A, Lampi A-N, Piironen V. Total plant sterols, steryl ferulates and steryl glycosides in milling fractions of wheat and rye. *Journal of Cereal Science*. 2007; 45(1):106-115. https://doi.org/10.1016/j.jcs.2006.08.003

18. Hidalgo A , Brandolini A. Kinetics of carotenoids degradation during the storage of einkorn (*Triticum monococcum* L. ssp. *monococcum*) and bread wheat (*Triticum aestivum* L. ssp. *aestivum*) flours. *J. Agric. Food Chem*. 2008 ;56(23):11300-5. http://doi:10.1021/jf802448t.

19. Kumar G , Krishna G. Studies on the nutraceuticals composition of derived oils wheat bran oil and wheat germ oil. *J. Food Sci. Technol*. 2015 ;52(2):1145-1151. http://doi.10.1007/s13197-013-1119-3. Epub 2013 Aug 10.

20. Zhu X, Zhou T , Wu X, Cai Y, Yao D , Xie C, Liu D. Covalent immobilization of enzymes within micro-aqueous organic media. *Journal of Molecular Catalysis B: Enzymatic*.2011; 72(3-4) 145-149. https://doi.org/10.1016/j.molcatb.2011.05.012

21. Association of Official Analytical Chemists (AOAC). Official Methods of Analysis of AOAC International. 16th ed. Arlington (VA): AOAC International; 1999. http://unida.ac.id

22. Meda A, Lamien C, Romito M, Millogo J, Nacoulma O. Determination of the total phenolic, flavonoid and proline Contents in Burkina Fasan Honey, as well as their radical scavenging activity. *Food Chemistry*. 2005;91(3):571-577. http://doi.10.1016/j.foodchem.2004.10.006.

23. Baba S, Malik S. Determination of total phenolic and flavonoid content, antimicrobial and antioxidant activity of a root extract of Arisaema jacquemontii Blume. Journal of Taibah University for Science. 2015;9(4) 449-454. https://doi.org/10.1016/j.jtusci.2014.11.001.

24. Serag El-Din M, Elsawy A. Utilization of coffee husks to prepare functional products. Suez Canal University Journal of Food Sciences.2021;8(1):19-28. https://doi.org/10.21608/scuj.2021.200308.

25. Akillioglu H, Karakaya S. Changes in total phenols, total flavonoids, and antioxidant activities of common beans and pinto beans after soaking, cooking, and in vitro digestion process. Food Sci. Biotechnol.,

2010;19 (3): 633-639. http://doi.10.1007/s10068-010-0089-8.

26. Gouveia S, Castilho. Antioxidant potential of Artemisia argentea L'Hér alcoholic extract and its relation with the phenolic composition. Food Research International.2011; 44:1620–1631. https://doi.org/10.1016/j.foodres.2011.04.040.

27. Benzie I, Strain J. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": the FRAP assay. Anal. Biochem. 1996;239(1):70-76. http://doi.10.1006/abio.1996.0292.

28. Gordon M, Kourimska L. The effect of antioxidant changes in oils during heating and deep frying. Journal of the Science of Food and Agriculture .1995; 68(3):347-353. https://doi.org/10.1002/jsfa.2740680314.

29. AOCS. Official and Tentative Methods of American oil Chemist's oil .3 nd Ed. Champion IL Washington, 1973; USA.

30. Abdel-Aal M, Karara H.Changes in corn oil during deep fat frying of foods. Lebensmittel-Wissenschaft+ Technologie. 1986;19(4):323-327. http://pascalfrancis.inist.fr/vibad/index.php?action=getRecordDetail&idt=7935691.

31. Pearson D, Surry J, Chuchill A. The chemical analysis of food national college of food technology. University Of Reading, Weybridge Surry T and A Churchill. 1970.

32. Farag R, Hallabo S, Hewedi F, Basyony A. Chemical evaluation of rapeseed. Fette, Seifen, Anstrichmittel. 1986; 88(10): 391-397. https://doi.org/10.1002/lipi.19860881006.

33. SAS Institute Inc.SAS/STAT user's guide. Release 6.03. Cary, NC: SAS Inst.1988.

34. El-Kholany A, Abdelmegeed M, Abd-Elraheem M, Deraz M, Elshaer M. Chemical evaluation and biological activity of olive leaves extract. Al-Azhar Journal of Agricultural Research. 2022; 47(1): 35-45. http://doi.10.21608/ajar.2022.266482.

35. Kabbasha E, Ayoub I, Abdel-Shakour Z, El-Ahmady S. A phytochemical study on Olea europaea L. Olive leaf extract (cv. Koroneiki) growing in Egypt. Archives of Pharmaceutical Sciences Ain Shams University. 2019;3(1): 99-105. https://doi.org/10.21608/aps.2019.45119.

36. Zayed S, Ashour A, Abd Alim M, Hassan M, Mekawi E. Determination and identification of the Biologically active compounds in olive leaves. Scientific Journal of Agricultural Sciences. 2024; 6 (2): 123-137. https://doi.org/10.21608/sjas.2024.284093.1412.

37. El-Feky A, Aboulthana M. Chemical composition of lipoidal and flavonoidal extracts from egyptian olive leaves with In vitro biological activities. Egyptian Journal of Chemistry. 2023 ;66(13):1903-1913. http://doi.10.21608/ejchem.2023.217533.8138.

38. Talhaoui N, Gomez-Caravaca A, Cristina R, León L, De la Rosa R, Fernanadez-Gutiérrez A, Segura-Carretero A. Chemometric analysis for the evaluation of phenolic patterns in olive leaves from six cultivars at different growth stages. Journal of Agricultural and Food Chemistry. 2015; 63(6). http://doi.10.1021/jf5058205.

39. Selim S, Albqmi M, Al-Sanea M, Alnusaire T, Almuhayawi M, Abd Elgawad H, et al. Valorizing the usage of olive leaves, bioactive compounds, biological activities, and food applications: A comprehensive review. Frontiers in Nutrition. 2022; 9: 1-27. https://doi.org/10.3389/fnut.2022.1008349

40. Manzoor S, Rashid R, Panda B, Sharma V, Azhar M. Green extraction of lutein from

marigold flower petals, process optimization and its potential to improve the oxidative stability of sunflower oil. Ultrasonics sonochemistry. 2022; 85:1-12. https://doi.org/10.1016/j.ultsonch.2022.105994

41. Ujong A. E., Emelike N. J, Owuno F, Okiyi P. N. Effect of frying cycles on the physical, chemical and antioxidant properties of selected plant oils during deep-fat frying of potato chips. Food Chemistry Advances. 2023; 3: 1-8. https://doi.org/10.1016/j.focha.2023.100338
42. Nayak P, Dash U, Rayaguru K, Krishnan K. Physio-chemical changes during repeated frying of cooked oil: A Review. Journal of Food Biochemistry. 2015; 40(3): 371-390. https://doi.org/10.1111/jfbc.12215.
43. Ali R, El Anany A. Recovery of used frying sunflower oil with sugar cane industry waste and hot water. Journal of food science and technology. 2014 ;51(11):3002-3013. http://doi.10.1007/s13197-012-0832-7.
44. Elhassaneen YA, ElBassouny GM, Hassan RH, Meharam EB. Application of natural extracts in beef meatballs to prevent chemical and bacteriological spoilage agents, and extend its storage life. Am J Food Sci Technol. 2023;11(4):118-30. http://doi 10.12691/ajfst-11-4-1
45. Kpata-Konan N, Yao N, Coulibaly K, Konan K. Determination of physico-chemical indices of frying oils used by A21ttiek´e-fish sellers in Daloa (Mid-West of Cote ˆ d'Ivoire). Food Nutr. Sci. 2020;11 (1): 52–62. https://doi.org/10.4236/fns.2020.111006.
46. Ghaly M, El-Khamissi H. Effect of deep frying on fatty acid composition and polymer content in sunflower and soybean oils. Journal of Agricultural Chemistry and Biotechnology. 2021;12(11): 189-194. http://doi10.21608/jacb.2021.208036.
47. Kedir W, Geletu A, Weldegirum G, Sima M. Antioxidant activity of selected plants extract for palm oil stability via accelerated and deep-frying study. Heliyon. 2023; 9(7):17980. https://doi.org/10.1016/j.heliyon.2023.e17980.
48. Li P, Yang X, Lee W, Huang F, Wang Y, Li Y. Comparison between synthetic and rosemary-based antioxidants for the deep frying of French fries in refined soybean oils evaluated by chemical and non-destructive rapid methods. Food Chem. 2021; 335:1-9. https://doi.org/10.1016/j.foodchem.2020.127638.
49. Abdo E, Shaltout O, Mansour H. Natural antioxidants from agro-wastes enhanced the oxidative stability of soybean oil during deep-frying. LWT. 2023;173(1):1-10. https://doi.org/10.1016/j.lwt.2022.114321.
50. Aydenız B, Yilmaz E. Performance of different natural antioxidant compounds in frying Oil. Food Technol. Biotechnol. 2016;54(1):21–30. http://doi.10.17113/ftb.54.01.16.4109.
51. Shahidi F. Quality assurance of fats and oils. [Wiley online library]; 2005. https://doi.org/10.1002/047167849X.bio072
52. Wang D, Chen X, Wang Q, Meng Y, Wang D, Wang X. Influence of the essential oil of *Mentha spicata cv. Henanshixiang* on sunflower oil during the deep-frying of Chinese *Maye*. LWT. 2020;122. https://doi.org/10.1016/j.lwt.2020.109020.
53. Guo Q, Gao S, Sun Y, Gao Y, Wang X, Zhang Z. Antioxidant efficacy of rosemary ethanol extract in palm oil during frying and accelerated storage. Industrial Crops and Products.2016; 94: 82–88.

https://doi.org/10.1016/j.indcrop.2016.08.032.

54. Basuny A, Arafat S, Kamel S. Polyphenolic compounds of eggplant peel juice as a natural antioxidant for the stability of sunflower oil during deep-fat frying. Current Research in Microbiology and Biotechnology.2013;1:1-8. http://crmb.aizeonpublishers.net/content/2013/1/crmb1-8.pdf.

55. Nanayakkara T, Wijelath W, Marso T. Deep-fat frying of vegetable oils: major chemical reactions and effect of natural extracts on oxidative stability - A Review. Sri Lankan Journal of Agriculture and Ecosystems.2020,2(2):81-102. https://sljae.sljol.info/articles/10.4038/sljae.v2i2.40.

56. Nor F, Mohamed S, Idris N, Ismail R. Antioxidative properties of Pandanus amaryllifolius leaf extracts in accelerated oxidation and deep-frying studies. Food Chem. 2008;110(2): 319-327. http://doi.10.1016/j.foodchem.2008.02.004.

57. İnanç,T. and Maskan, M. Effect of carvacrol on the oxidative stability of palm oil during frying. Grasas Aceites.2014; 65 (4):42-51. http://dx.doi.org/10.3989/gya.0350141.

58. Romano R, Giordano A, Paduano A, Sacchi R, Musso SS. Evaluation of frying oil subjected to prolonged thermal treatment: volatile organic compounds (VOC) analysis by DHS-HRGC-MS and H-NMR spectroscopy. Chem Eng Trans. 2009 May 20;17:879-84. http://academia.edu

59. Lalas S. Quality and stability characterization of Moringa oleifera seed oil. [PhD thesis] England, University of Lincolnshire and Humberside ;1998.

60. Zahran H, Najafi Z. Enhanced stability of refined soybean oil enriched with phenolic compounds of olive leaves. Egyptian .J. Chem. 2020; 63(1):215 – 224. https://dx.doi.org/10.21608/ejchem.2019.16592.2010.

61. Dunford N. Oxidative Stability of Sunflower Seed Oil. Sunflower.AOCS Press;2015. https://doi.org/10.1016/B978-1-893997-94-3.50021-0.

62. Zhang Q, Wan C, Tian J, Qi D, Liu S, Wu D, etc . Use of ethanol extract of Chuanminshen Violaceum to inhibit the deterioration of frying oil. Industrial Crops and Products.2020; 155:1-10. https://doi.org/10.1016/j.indcrop.2020.112808.

63. Wang F, Sun Y, Li S, Yan J, Qin W, Saleh A, Zhang Q. Plant phenolic extracts for the quality protection of frying oil during deep frying: Sources, effects, and mechanisms. Grain & Oil Science and Technology. 2023; 6(3):148-161.

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تأثير بعض مضادات الأكسدة الطبيعية والصناعية على ثبات زيت عباد الشمس اثناء التحمير الغزير

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الملخص العربى:
تعتبر مشكلة تزنخ وفساد الزيوت أثناء القلى من المشاكل الخطيرة التى تواجه الناس فى جميع أنحاء العالم، ويبذل العلماء المزيد من الجهود لحل أو تقليل الآثار الجانبية لهذه المشكلة عن طريق إضافة مضادات الأكسدة الطبيعية أو الاصطناعية إلى الزيت أثناء القلى. مضادات الأكسدة هى مركبات عضوية أو غير عضوية تساعد على تقليل أكسدة الدهون وزيادة استقرار الزيوت أثناء القلي. تهدف هذه الدراسة إلى مقارنة كفاءة وأمان مضادات الأكسدة الطبيعية (مستخلص كلا من أوراق الزيتون وجنين القمح) بمضادات الأكسدة الاصطناعية (جالات البروبيل) لتقليل التزنخ أثناء عملية القلى. فى الدراسة الحالية، تمت إضافة 200 ملجم من مستخلص أوراق الزيتون أو جنين القمح أو مسحوق جالات البروبيل إلى زيت عباد الشمس المسخن عند 180 درجة مئوية لمدة 12 ساعة (200 ملجم من المستخلص: كيلو جرام من زيت عباد الشمس). تم إجراء العديد من الاختبارات للتحقق من جودة الزيت مثل الخصائص الفيزيائية (اللون، معامل الانكسار، الديين، والترين) والتحاليل الكيميائية (رقم الحموضة، قيمة البيروكسيد، رقم التصبن، الرقم اليودى، البنزيدين، ومحتوى حامض الثيوباربيتيوريك). بالإضافة إلى ذلك، تم قياس قدرة مضادات الأكسدة على كسح أنواع الأكسجين التفاعلية (ROS) عن طريق اختبارات مضادات الأكسدةDPPH) ، ABTS، و (FARP) . كما تم قياس محتوى الفينولات الكلية والفلافونويدات الكلية فى هذه المستخلصات. بشكل عام، حافظت الخصائص الفيزيائية والكيميائية للزيت المسخن بمضادات الأكسدة معنويا بشكل كبير ($p\leq0.05$) على جودة الزيت أثناء القلى. تم ترتيب كفاءة مضادات الأكسدة على النحو التالى: مستخلص أوراق الزيتون > مستخلص جنين القمح > جالات البروبيل، وكانت أفضل فترة قلى عند 4 ساعات.

الكلمات الكاشفة: أوراق الزيتون، جنين القمح، التحمير الغزير، مضادات الأكسدة

الاستشهاد الي:
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