EFFECT OF ADD SOME AROMATIC PLANTS ON THE STABILITY OF THE OXIDE FRYING OILS

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Abstract:

The present study was carried out to achieve the following objectives:

1. Studying the time-temperature relationships during frying operations using designed frying protocol.

2. Investigating the effect of frying process on the quality parameters of frying oilused. The different suggested treatments that carried out in this investigation could be summarized with their abbreviations as follows:

Treatment (T): Control Without any additives

Palm olein (PO)

T1 PO+ 0.2% rosemary extracted (RE)

T2 PO+ 0.2% Sage extracted (SE)

T3 PO+ 0.2% Basil extracted (BE)

T4 PO+ 0.2% Butylated hydraxy touloene (BHT). The palm olein was heated to 60°C before addition of oil extracts (0.2%) rosemary; sage or basil then stirred to ensure that it was completely dissolved. BHT-containing palm olein (0.02%) and control samples (without any antioxidant) were used as positive and negative control. All frying oil samples were heated at frying temperature in about 2 minutes to elevate temperature from 25 to 180°C, followed by addition of potato chips at a

rate of 400 g in 5 liters frying oil for 21/2 minutes to complete frying process in the 1st cycle of frying. The 2nd (heating and cooling) cycle of frying process was carried out after 1/2 min. When the frying oil temprature raised again from about 170 to 180°C and potato chips was added at a rate of 400 g to 4970cm3 frying oil no need to oil loss compensation due to loss of this small amount of frying oil (0.6%). This process was repeated 10 times at the 1st day of the experiment. The experimental ended after 50 frying processes at the 5th day. Samples were withdrawn at 0 time (60°C) then after 10, 30 and 50 frying processes at the 5t day. Samples size was 250ml for chemical and physicochemical analysis and 250 ml for biological assay. Deep frying experiments were carried out simultaneously using an aluminium open fryer with a concave shape which is almost used in all frying restaurants in Egypt and mainly sold in El-Qamalyia district. This frying pan capacity was 10 litre oil and equipped with autolift aluminum basket. The oil in each fryer was filtered to remove debris using separate filters.The same frying process was repeated three times in three consecutive weeks and withdrawn samples from each trial were mixed together to form a representative composite sample. After frying operations, the frying products were weighed and after each 10 fryings, samples were withdrawn and stored in brown bottles in a deep freezer at -20°C until analysis. Oil (250m1) was sampled from each frying medium to represent 0, 10, 30and 50 frying cycles, consecutive up to 5 days, and was kept in amber bottles. Oil samples were flushed with slow bubbles of nitrogen free the botton of the bottles and stared in freezer at 20°C for physical and chemical analysis. The same sample weight was also with drown for biological evaluation.

After frying, the chips were removed from the frying pan and sensory evaluation was conducted in the same day using all batches of potato chips (0, 10, 30 and 50 fryings). The ratio between potato weight and frying oil volume (w/v) was almost stable depending on oil loss two samples of oil, each weighing 225gm, one for phesical and chemical analysis and the 2nd one for biological assay were taken. The whole procedure was repeated consecutively for 7 days. Results showed that. The No. of frying (times of frying) has a significant effect on peroxide value of all samples. The peroxide values increased with increasing no. of

fryings until the 50th frying. artificial (BHT) or natural (rosemary, sage and basil) did not have the ability to inhibit peroxide formation even after only 10 fryings. On the other side, these antioxidants reduced the percentage of peroxide formation from about 65% to only 20-22% (rosemary, sage, basil and BHT). Ansidine value was clearly affected by No.of fryings as a general trend in case of T1, T2and T3 similar to that of control one. it could be report that using chemical (artifichial) antioxidant did not prevent the ditremental effect of frying times compaired with using natural antioxidants. On the other hand, use of natural or artificial antioxidants (T1, T2, T3, T1 and T4) minimized ansidine value by about 1.1 folds from control sample at any number of frying. Totox value of unheated palm olein with or without antioxidants was ranged between 17.90 to 20.17. It is of great importance to mention that there was no significant difference between all samples either untreated or treated with natural or artificial antioxidants at F0.

Addition of herb extracts (0.2%) was significantly natural or articifical extracts lowered the totox value significantly ($P \leq 0.05$) compared to the control after 10 fryings with about 1.2 folds (for all treatments) less than control one. Totox value of unheated palm olein with or without antioxidants was ranged between 17.90 to 20.17. It is of great importance to mention that there was no significant difference between all samples either untreated or treated with natural or artificial antioxidants at F0.

Addition of herb extracts (0.2%) was significantly natural or articifical extracts lowered the totox value significantly ($P \leq 0.05$) compared to the control after 10 fryings with about 1.2 folds (for all treatments) less than control one. Iodine number did not affect by the type of antioxidant use as seen at F0 treatment; i.e. no significancy was found (values were around 56-58). Thiobarbituric acid number (TBA) value did not affect by only the type of antioxidant (as seen at F0 treatment). But, when frying process was taken place the TBA value was increased by about 2 folds after 10 fryings for all treatments. After 30 times of frying, the increasing in TBA value reached to be 3 folds for all treatments and sharply increased to be about 4.5 folds that of their initial values (at F0) for all treatments. Acid value of various treatments was praparationaly correlated with No. of fryings. A significant difference was also noticed between treatments. The (F50) treatment recorded the highest acid value. Frying times (No. of

fryings) were clearly affected scuh parameter (viscosity) in case of T3 and T4 treatments. It reached to 107.14 and 109.13 in T3 and T4, respectively after 50 times of frying. Meanwhile, it was ranged between 84.41 to 96.89 in other treatments after the same No. of fryings. the higher the frying times, the higher the polar value; i.e. there is a proportional relationship between polar value and number of fryings . No significant differences were detected between treatments as affected by using natural (Sage, rosemary and basil) and or artificial antioxidant (BHT). Such finding was noticed in all organalyptially evaluated parameters, i.e. appearance, odor, color, taste, texture and overall acceptability. Mean values were between 6.33-8.33. It could be concluded that using antioxidant either natural or artificial one did not organaloptically effect by type of antioxidant when the product or used oil were considered.

Key words: Aromatic plants, palm olein, peroxide value, ansidinevlaue, iodine value.

Introduction:

Deep-fat frying is one of the most commonly used practices in food preparation and manufacture all over the world. The increased consumption of fired foods is due to an increased number of restaurants serving convenience foods such as fried chicken, French fries and potato chips. More than 500 million pounds of edible fats and oils, for example, are used annually for the manufacture of potato chips in the United States alone (Irwandi&Che Man 1999).

Deep fat frying is a popular way to prepare a variety of foods. When food is fried in heated oil, many complex chemical reactions occur and the oil begins to degrade. The triglyceride molecule breaks down into both volatile and nonvolatile compounds which are soluble in the oil. These components contribute to both the desirable and undesirable sensory characteristics of food fried in oil. Natural triglycerides comprising an oil are considered non polar material. The products of the oil degradation are defined as polar compounds (Hassan, 2001).

The scientific literature is replete with studies questioning the safety of heated fats and oils. It is will established that heating of fats can results in formation of compounds with antinutritional properties. Compounds

formed may be enzyme inhibitors, vitamin destroyers, lipid oxidation products, gastrointestinal irritants and/or potential mutagens (Hassan, 2001).

Materials and Methods:

1. Materials:

1.1 Essential oils:

Essential oils of sage (*Salvia officinalis*), basil (*Ocimumbasilicum*) and rosemary (*Rosmarenusofficinalis*) were obtained from unit of pressing and extracting natural oils, National Research Centre, Giza, Egypt.

1.2. Potato:

From Local markets.

1.3. Palm olien oils:

Refined bleached and deodo ringed palm olein free from additivies was kindly supplied from Arma Food Industry Company, 10th Ramadain City, Cairo Egypt**.**

1.4. Chemicals:

All solvents and chemicals were used either analar or of analytical grade unless otherwise specified. Acetic acid-isooctane-potassium iodide-sodium thiosulphat and starch were obtained from Sigma-Aldrich GmbH, Steinheim.

1.5. Treatments:

The different suggested treatments that carried out in this investigation could be summarized with their abbreviations in Table (1).

Table (1): Suggested treatments for using various antioxidants (natural and /or chemical) in frying oil.

Item	Treatment palm Olein (PO)
Control	Without any additives
T1	PO+ 0.2% rosemary essential oil (R)
T2	PO+ 0.2% Sage essential oil (S)
T3	PO+ 0.2% Basil essential oil (B)
T4	PO+ 0.02% Butylatedhydraxytouloine (BHT)

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine

1.6. Preparation of palm olein to frying process:

The palm olein was heated to 60°C before addition of oil extracts (0.2%) rosemary; sage and basil then stirred to ensure that it was completely dissolved. BHT- containing palm olein (0.02%) and control samples (without any antioxidant) were used as positive and negative control, respectively.

1.7. Preapattion of potato chips:

1.7.1. Frying protocol:

All frying oil samples were heated at frying temperature in about 2 minutes to elevate temperature from 25 to 180°C, followed by addition of potato chips at a rate of 400 g in 5 liters frying oil for 21/2 minutes to complete frying process in the 1st cycle of frying. The 2nd (heating and cooling) cycle of frying process was carried out after 1/2 min. When the frying oil temp. raised again from about (170 to 180°C) and potato chips was added at a rate of 400 g to 4970cm3 frying oil no need to oil loss compensation due to loss of this small amount of frying oil (0.6%). This process was repeated 10 times at the 1st day of the experiment. The experimental ended after 50 frying processes at the 5th day. Samples were withdrawn at 0 time (60°C) then after 10, 30 and 50 frying processes at the 5th day. Samples size was 250ml for chemical and physicochemical analysis and 250 ml for biological assay.

1.7.2. Description of frying experiments:

Deep frying experiments were carried out simultaneously using an aluminium open fryer with a concave shape which is almost used in all frying restaurants in Egypt and mainly sold in El-Gamalyia district. This frying pan capacity was 10 litre oil andequipped with autolift aluminum basket. The oil in each fryer was filtered to remove debris using separate filters.

The same frying process was repeated three times in three consecutive weeks and withdrawn samples from each trial were mixed together to form a representative composite sample.

After frying operations, the frying products were weighed and after each 10 fryings, samples were withdrawn and stored in brown bottles in a deep freezer at -20°C until analysis. .

Oil (250m1) was sampled from eachfrying medium to represent 0, 10, 30and 50 frying cycles, consecutive up to 5 days, and was kept in bottles. Oil samples were flushed with slow bubbles of nitrogen free the botton of the bottles and stared in freezer at 20°C for physical and chemical analysis. The same sample weight was also withdrown for biological evaluation.

After frying, the chips were removed from the frying pan and sensory evaluation was conducted in the same day using all batches of potato chips (0, 10, 30 and 50 fryings). The ratio between potato weight and frying oil volume (w/v) was almost stable depending on oil loss two samples of oil, each weighing 225gm, one for phesical and chemical analysis and the 2nd one for biological assay were taken. The whole procedure was repeated consecutively for 7 days.

2. Methods of Analysis:

Changes in oil quality attributes, such as; i.e. peroxide value, anisidine value, iodine value, free fatty acids, oxidative stability index (OSI), polar compounds, polymers and colour test were followed by the methods recommended by American Oil Chemists Society Official AOCS (**2005)**. Determination of French fries colour was done using a colorimeter.

3. Sensory evaluation:

Sensory evaluation of potato chips including overall acceptability was evaluated using a 10 point headanic scale where 1= very poor and 10= excellent. Sensory evaluation was done by 10 trained panelists. The frying oil samples were evaluated by its colour, odor and subjected to the same 10 point headonicsacle.

6. Statistical analysis:

Each analysis was done in triplicate. The Mini TAB 14 softwear was used to analyze data for determining ANOVA, standard deviation and Duncan's multiple range test for significance level at 5%.

Results and Discussion:

1. Peroxide value (P.V.):

Peroxide value represents primary reaction products of lipid oxidation, which can be measured by their ability to liberate iodine from potassium iodide. Addition of herbs (rosemary, sage and basil) as well as BHT did not affect peroxide value compared to the control as given in Table (2). After 10 fryings, the P. V increased from 4.8 to 7.9 meq/kg oil with about 64.6% increase. Whereas rosemary, sage and basil have increased by 19.88, 22.22 and 20.41%, respectively. An artificial antioxidant (BHT) used in the present investigation did not succeed to rezest up to 20 oxidation caused by resist frying operon. On conclusion, artificial (BHT) or natural (rosemary, sage and basil) did not have the ability to inhibit peroxide formationeven after only 10 fryings. On the other side, these antioxidants reduced the percentage of peroxide formation from about 65 to only 20-22% (rosemary, sage, basil and BHT). This indicates that the efficiency of the selected antioxidants either natural or synthetic, at this stage of frying operation have had almost similar efficiency in retarding palm olein oxidation.

The effect of various levels and types of anti-or pro-oxidants could be studied. Phenolic compounds from plants are known to be good natural anti-oxidants. However, the activity ofartificial antioxidant was often observed to be higher than that of natural anti-oxidants (Ningappa*et al*., 2007). Phenolic compounds, at certain concentrations, markedly slowed down in the rate of conjugated diene formation (Chimi & Cilard, 1991). In their absence, linoleic and concentration decreased dramatically, indicating oxidtion. The antioxidant effectiveness of these compounds seemed to be related to their ability to quench peroxyl radicals.

Peroxide values obtained in this study were similar to the trends of the antioxidative effect (Morteza-Semnani*et al*., 2006). The peroxide value was decreased after some hours of heating, indicating formation of secondary oxidation products, such as ketones, aldehydes, hydrocarbons and epoxides, which could be measured using the anisidine test Hindered phenols (caffeic acid, venillic acid and ferrulic acid) and crude tea extract reportedly lower the peroxide value and anisidine value at 0.02% concentration in oil (Abdulkarim*et al*., 2007).

Results of Table (3) also indicate that the No. of frying (times of frying) has a significant effect on peroxide value of all samples. The peroxide values increased with increasing no. of fryings until the 50th frying. In

control samples peroxide values increased by 65.48, 180.54 and 255.23% after 10, 30 and 50 fryings, respectively. The peroxide value of rosemary treated palm olein increased by 14.71, 122.06 and 203.97% after 10, 30 and 50 fryings, respectively. Sage treated palm olein subjected to a corresponding increase in peroxide values after 10, 30 and 50 fryings by 41.74, 183.25 and 263.83%, respectively. Basil treated pall olein subjected to a corresponding increase in peroxide values after 10, 30 and 50 fryings by 26.61, 159.88 and 245.97%. Artificial antioxidant, BHT added to palm olein caused an inhibitory effect on peroxide formation that retarded its rate to be 18.56, 135.02 and 224.05% increase compared to the control.

The elucidate the efficiency of each used antioxidant either natural or artificial in the present investigation, the responsibility of frying operation on the rate of peroxide formation (Table 3) could be calculated. For example, in control sample if operation in the 1st 10 fryings caused 6.5% increase in peroxide value whereas it caused 1.47, 4.17, 2.66, 1.85% in and BHT, respectively.

At the 30th, frying the control shows 6.02% P.V increase/ day compared to 4.07, 6.1, 5.3 and 4.5% increase day in R, S, B. and BHT. This indicates that the efficiency of in retarding lipid oxidation is almost disappeared 6.02 versus 6.1 in sage + palm olien samples. All other samples, R, B and BHT, show also less efficiency in retarding lipid oxidation when compared with theirefficiencies during the 1st 10 fryings (1.47, 2.66 and 1.85 versus 4.07, 5.3 and 4.5).

This means that, a progressive and dramatic increase in peroxide formation has been occurred from 10th to 30th frying. At the stage between 30th to 50th fryings, the rate of P.V formation was either stable (R and BHT) or became less (control, sage and BHT).

Table (2): Peroxide value of different frying oil sample treatment with different antoxidants

No. Frying / Treatment	F0	F10	F30	F50
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	4.78a±.20	7.91a±.30	13.41a±.09	16.98a±.22

T1	5.03a±.56	5.77b±.39	11.17a±.77	15.29b±.15
T2	4.74a±.13	5.62b±.51	11.14b±.16	15.36b±.48
T3	4.48a±.46	6.35b±.61	12.69a±.63	16.30ab±.78
T4	4.96a±.25	6.28b±.48	12.89a±.26	17.16a±.49
LSD	0.655	0.854	0.845	0.870

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level. T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein+0.2% Basil; T4: Palm Olein+0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

Table (3): Efficiency of different antioxidants added to palm olein

Treatment	No- of frying		
	10	**30**	**50**
% increase	65.48	180.54	255.23
DPV/ D No.frying	6.5%	6.02%	5.1%
Control			
DPV/ D No. frying	14.71	122.06	203.97
T1	1.47%	4.07%	4.06%
DPV/ D No. frying	41.74	183.25	263.83
T2	4.17%	6.1%	5.26
DPV/ D No. frying	26.61	159.88	245.97
T3	2.66%	5.3%	4.9%
T4 BHT	18.56	135.02	224.05
DPV/ D No. frying	1.85%	4.5%	4.48%

2. Ansidine value:

Data given in Table (4) indicate ansidine value as affected by various suggested treatments in this study. From these data it could be noticed

that, ansidine value was clearly affected by No.offryings as a general trend in case of T1, T2and T3 similar to that of control one. Ansidine value was increased by 1.45 folds after ten fryings then raised to be 2 folds (rather than their values at zero time frying) and it continuously raised to be 2.55, 2.66 and 2.81 folds in T1, T2 and T3, respectively. Regarding to T4 treatment it could be seen that earliar incremental trend in insidine value was more detected. The corresponding increasing folds are 1.60, 2.15 and 3.00 after 10, 30 and 50 frying ascalculated from table (4). So, it could be report that using chemical (artifichial) antioxidant did not prevent the ditremental effect of frying times compaired with using natural antioxidants (Subramanian *et al*., 2000 and Buczek and Chwialkowski 2008).

On the other hand, use of natural or artificial antioxidants (T1, T2, T3 and T4) minimized ansidine value by about 1.1 folds from control sample at any number of frying.

Antioxidants have had a specific activity based on its ability to compensate protons that leave behind free radicals which initiate auto oxidation reaction chain. Highly mobile and active free radicals react with O2 if the antioxidants proton did not replace that belong to fatty acids free radical which lose theirproton. Rosemary was found to be the most active antioxidants when compared not only with other natural ones but also when compared with artificial one called BHT.

Decompose to secondary products, including alcohols, carboxylic acids, aldehydes and ketones, measured as insidine value. The ansidine value was independent of the extract type but was significantly different from the control (Table 4).

Table (4): Ansidine value of different frying oil sample treatment with different antoxidants

No frying / Treatments	F0	F10	F30	F50
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	9.66a±0.44	14.03a±0.43	19.32a±0.45	26.49a±1.07
T1	8.63a±0.57	12.54b±0.68	17.25c±0.57	22.03b±0.87

T2	8.42a±0.83	12.28b±0.50	16.96c±0.45	22.41b±1.64
T3	9.07a±0.81	13.04ab±0.40	17.85bc±0.17	25.51b±0.47
T4	8.64a±0.66	13.86b±0.18	18.56ab±0.58	25.92a±1.12
LSD	1.235	0.850	0.853	2.004

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

3. Totox value (Total oxidation):

Totox value is the most important in discussing the degree of oxidation process which has been occurred in frying oils (Table 5). Totox value of unheated palm olein with or without antioxidants was ranged between 17.90 to 20.17. It is of great importance to mention that there was no significant difference between all samples either untreated or treated with natural or artificial antioxidants at F0.

Addition of herb extracts (0.2%) was significantly natural or articifical extracts lowered the totox value significantly (P> 0.05) compared to the control after 10 fryings with about 1.2 folds(for all treatments) less than control one Miyagi and Nakajima (2003).

After 10 frying the totox value of control palm olein (B) decreased by, 19.33, 13.77, 11.49 and 21.21% (BHT). Overall results suggested that both natural and synthetic antioxidants were capable of protecting the oil from further oxidation, resulted from frying operations, compared to the control one. The ability to lower the rate of antoxidation was good in both R and BHT (19.33 and 21.21%, respectively) whereas in S and B it was higher (13.77 and 11.49 respectively), i.e. less ability to retard antioxdiation process during frying till the 10th frying was still present.

At the 30, 50th frying, another concept could be concluded both S and B loose their ability to retard autoxidation, i.e become either inactive or prooxidant, that is why both of them did not differ significantly with the control are ((Table 5) although up to the 30th frying they still act as

antioxidants. On the other hand R and BHT were capable of protecting oil form further oxidation compared to the control. Rosemary as antioxidant was comparable to BHT, however there was no significant difference between both as appeared in Table (5).TOTOX = 2PV + P – AV (Shahidi and Wanasundara 2002).

Table (5): Totox value of different frying oil sample treatment with different antoxidants

No frying / Treatments	F0	F10	F30	F50
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	1922ab±0.28	29.86a±0.91	46.15a±0.61	60.44a±1.01
T1	2.17a±0.27	24.08b±1.26	39.60b±1.97	52.43b±1.28
T2	17.90b±1.04	23.52b±1.51	39.25b±0.35	53.13b±2.49
T3	18.04ab±1.13	25.75b±1.50	43.24a±1.08	58.11a±1.11
T4	18.56ab±0.94	26.43b±0.80	44.04a±0.66	60.23a±1.83
LSD	1.500	2.243	0.853	2.9852.985

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

4. Iodine number:

Table (6) indicate changes in iodine number of different frying oil samples treated with different antioxidants. It could be seen that, such parameter (iodine number) did not affect by the type of antioxidant use as seen at F0 treatment; i.e. no significancy was found (values were around 56-58).

Similar trend was extended till 10 frying but with lesser values (around 49-51). Meanwhile, when frying was carried out to be 30 times, treatments were significantly differed and such findings were also detected in iodine number (with more effect) after 50 fryings(Nor *et al.*, 2008).

Table (6): Iodine number of different frying oil sample treatment with different antoxidants

Treatments	F0	F10	F30	F50
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	57.77a±0.41	48.82a±0.43	39.80a±0.51	33.33c±1.03
T1	55.81a±1.11	49.84a±0.97	43.26a±1.07	38.56a±0.55
T2	56.93a±1.18	49.65a±1.23	43.36a±0.43	37.58ab±0.65
T3	57.24a±0.57	50.91a±0.34	42.55ab±1.37	36.96ab±1.09
T4	56.28a±0.35	49.04a±0.67	40.41bc±1.24	35.77b±1.05
LSD	1.467	1.450	1.823	1.643

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

5. Thiolbarbituric acid (TBA) value:

Thiolbarbituric acid (TBA) values of different frying oil samples that treated with different antioxidants suggested in this study were given in Table (7) from these table and figure it could be concluded that, TBA value did not affect by only the type of antioxidant (as seen at F0 treatment). But, when frying process was taken place the TBA value was increased by about 2 folds after 10 fryings for all treatments.After 30 times of frying, the increasing in TBA value reached to be close to 4 folds for all treatments and sharply increased to be about 4.5 Folds that of their initial value (at F0) for all treatments as calculated from Table (7). Such findings go in parallel with those, Nguyen *et al.* (2015).

Table (7): TBA value of different frying oil sample treatment with different antoxidants

Treatments	F0	F10	F30	F40
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	11.62a±0.42	24.93a±2.14	41.76a±3.59	53.26s±4.58
T1	11.52a±1.09	21.37b±1.86	37.59b±3.26	51.10a±0.50
T2	12.19a±0.70	21.05b±1.72	37.53b±3.07	50.67a±4.15
T3	12.09a±0.96	22.81ab±1.88	38.81ab±3.24	53.01a±4.38
T4	11.46a±0.81	21.88b±1.91	38.85ab±3.39	52.88a±4.61
LSD	1.511	1.912	2.273	2.014

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

6. Acid value:

Acid value % as affected by different suggested antioxidants used in this investigation. From these data it could be seen that, from these data it could be seen that, acid value% of various treatments was praparationaly correlated with No. of fryings. A significant difference was also noticed between treatments a seen in table (8). The (F50) treatment recorded the highest acid value percent.

Table (8): Acid value % of different frying oil sample treatment with different antoxidants

Treatments	F	F10	F30	F40
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.
Control	0.69a±0.01	1.20a±0.26	1.97a±0.23	2.60a±0.17
T1	0.63b±0.03	0.74b±0.04	1.10b±0.18	1.57b±0.06

T2	0.66ab±0.01	0.85bc±0.02	1.26b±0.04	1.65b±0.10
T3	0.66ab±0.02	0.96abc±0.02	1.30b ±0.17	1.60b±0.04
T4	0.68a±0.02	1.09ab±0.09	1.37b±0.06	1.67b±0.06
LSD	0.030	0.227	0.281	0.1790.179

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No. Frying at 50 times

7. Viscosity:

Changes in viscosity of frying media that carried out in this investigation were shown in Table (9). It was seen that frying times (No. of fryings) were clearly affected scuh parameter (viscosity) in case of T3 and T4 treatments. It reached to 107.14 and 109.13 in T2 and T4, respectively after 50 times of frying. Meanwhile, it was ranged between 84.41 to 96.89 in other treatments after the same no. of fryings. These findings are in agreement with those of Lin *et al*. (1999) and Chatzilazarou*et al*. (2006).

Table (9): Viscosity value of different frying oil sample treatment with different antoxidants

Treatments	**F0**	**F10**	**F30**	**F50**	**LSD**
	Mean±S.D.	**Mean±S.D.**	**Mean±S.D.**	**Mean±S.D.**	**(0.05)**
Control	72.86 ±2.40	79.18 ±2.40	84.00 ± 2.41	92.86 ± 2.04	4.52
T1	54.45 ±2.40	61.58 ±2.40	71.69 ± 2.40	84.41 ± 2.40	4.52
T2	68.71 ±2.40	76.66 ±2.40	86.59 ± 2.40	96.89 ± 2.40	4.52
T3	83.38± 2.40	91.32 ±2.40	97.17 ± 2.40	107.14±2.40	0.227
T4	83.98 ±2.40	90.93 ±2.40	98.45 ± 2.40	109.13±2.40	4.52

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

8. Polar value:

Data given in Table (10) showed that the polar value of frying oil samples as affected by times of frying and/ or suggested additives as antioxidants. From this table it could be seen that generally, the higher the frying times, the higher the polar value; i.e. there is a proportional relationship between polar value and number of fryings.

Meanwhile, a contradicted relationship was clearly noticed among type of treatment (natural or artificial one) as seen in the same table. Such relation did not detect at zero time of frying, then a continuous decrease was recorded with various rates depending on type of treatment (Chatzilazarou*et al*., 2006 and Romero *et al*., 2006).

Table (10): Polar value of different frying oil sample treatment with Control different antoxidants

Treatments	F0	F10	F30	F50	LSD (0.05)
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	
Control	4.45 ±0.46	9.03 ±0.29	17.70 ±2.21	26.19 ±1.00	2.27
T1	4.14 ±0.15	6.09 ±0.08	12.99 ±0.77	21.39 ±0.28	0.76
T2	4.07±0.16	8.15 ±0.23	14.37 ±0.92	24.98±0.18	0.89
T3	4.06±0.07	7.61 ±0.59	14.05 ±0.19	24.05 ±0.15	4.52
T4	4.14 ±0.09	6.64 ±0.39	13.17 ±0.22	22.84±0.69	0.75

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

T1: Palm Olein + 0.2% Rosemary; T2: Palm Olein + 0.2% Sage; T3: Palm Olein + 0.2% Basil; T4: Palm Olein + 0.02% Butylatedhydraxytouloine; F0:Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

9. Fatty acid composition:

Linolenic acid and linoleic are highly sensitive to oxidation because it contains three and two double bands while Oleic acid is less reactive and more heat stable, it contains only one double bond. The fatty acid profile is also relevant to its nutritive quality and how it changes during frying process, (Kris Ethertone*t al*., 2004).

Palm olein it relatively contains a highly amount of C18:2nd and C18:1n9 as 25.033 and 37.783, respectively. This is give the oil or palm olein health and advantage on stability of oil and cardiovascular disease has been claimed (Kris ethertone*t al*., 2004).

The linoleic acid is also precause of long chain omega-3 poly unsaturated FA (LC n-3 PLFA) by elongation Enzymatic conversion (Simpoulos, 1997). The change is unsaturated Fas during frying is show in Table (16). There was a significant decrease in (18.2n6 to range between 39% -45% along frying process on palolein from F0 up F50, Goli *et al.* (2012).

The fatty acid profile of edible oil effect during theral of frying temp. Both linolenic acid (C18:3) and (C18:2) were highly sensitive to frying temperature because it contains more than two double bonds, while oleic acid C18:1 is less reactive as it contains only one double bond. Addition off different phenolic compounds are show similar effects on C18: 2n6. There were a failed from 25-037 is control belondoil in to about 11%. Table (11) shows the statistically result of natural antioxidant roles in stability of oil waste significantly increase sage frying oil. All moded of palm okinfryings there were a significant decreases occurred in C18:2nb, follows by C18.3n3. Vice reverse. There were increased in C18: inq in all frying mode about 10-15% in comparison to control blend oil (FO), Goli *et al.* (2012).

The basil extracted when added into palm olein was effected on increase stability of oil and protect the oil from destruction especially as show in C18:2nd. In frying Fio, F30 and and F50, 10.406, 10.769 basil extracted when add in to palmolein. Meanwhile, Rosemary extract in palmoile in used in frying especially is F50 was protect W-3 fatty acid from destruction as 9.167 with long time heating. This is means that rosemary extraction in frying oil were healthy than either basil or sage in frying palnolein. As a conclusion, Both basil and rosemary extracts were shown

increasing stability of palm olein similar to synthelic antioxidant BHT, Goli *et al.* (2012).

9.1. Fatty acids profile of frying samples:

Data given in Tables (7.11) showed the fatty acids profile of different frying oil sample as affected by adding various natural and /or artificial antioxidants as well as by times of frying.

9.2. Untreated (control) sample:

From Table (11) that indicated frying number effect on control sample, it could be noticed that, C16:0 was the predominant saturated fatty acid (23.806%) and it increased after ten frying till the end of experiment (50 fryings) to be about 37%. The C18:0 was found to be in the second order with approximathy constant percentage (about 4%).

It is of interest to notice that sum. of saturated fatty acids was continuously raised as number of fryings raised. Such raising was started after ten times of frying them slowly increased by times of frying increased.

From the same Table (11), it could be also seen the unsaturated fatty acids profile as affected by two factors mentioned above. The predominant unsaturated fatty acid was C18:1n9 that behaved similar trend that mentioned above in case of C16:0 but with the percentage of 37.783% increased to be about 43%.

Table (11): Fatty acid profile (%) of different control frying oil samples

Number of frying				
Fatty acid	**F0**	**F10**	**F30**	**F50**
C12:0 (Lauric)	0.401	0.137	0.252	0.259
C14:0 (Myristic)	1.938	0.945	0.902	1.094
C16:0 (Palmitic)	23.806	36.076	36.681	37.392
C18:0 (Stearic)	4.184	3.706	3.888	4.174
C20:0 (Arachidic)	0.15	0.333	0.321	0.154
Sum of SFA	30.479	41.197	42.044	43.073

C16:1n7 (Palmitoleic)	0.871	0.243	0.282	1.006
C18:1n9 (Oleic)	37.783	43.317	43.692	42.368
C18:1n7 (Vissinic)	0	1.203	1.203	1.618
C18:2n6 (Linoleic)	25.033	11.491	11.279	10.817
C18:3n3 (Linolenic)	2.106	0.227	0.185	0.222
Sum of USFA	65.793	56.481	56.641	56.031
Other Fatty Acids	3.728	2.32	1.31	0.9

F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

The C18:2n6 that came in the second order (25.033%) was sharply reduced by over 50% of its original percentage as a resultof extending frying treatment (number of fryings). The sum of unsaturated fatty acids was minimized after ten fryings by about 9% then still constant till the end of experiment (50 fryings). These findings are in agreement with those.

9.3. Basil sample:

Table (12) indicated that fatty acids profile of different frying oil samples as affected by adding basil extract (as a natural antioxidant) as well as by times of frying. From this table it could be seen that C16:0 fatty acid was a predominant one with about 39%. It did not affect by extending the times of frying (till 50 times).

The C18:0 came in the second order with values around 4% and it behaved similar trend that noticed earlier. Generally, it could be noticed that sum. of SFA (about 45%) did not affect by times of frying comparing with control sample (Table 11)as shown earlier. It means that basil extract plays a noticeable role as antioxidant.

On the other hand, C18:1n9 was appeared as a predominant unsaturated fatty acid with about 41%. Similar detected basil effect as a good antioxidant was recorded as a function of time of frying. In the second order with about 11%, C18:2n6 also approximately not affected by times of frying (till 50 times). The total USFA also did not affect awing to

frying times. It was about 54%, this assures the role of basil as antioxidant.

Table (12): Fatty acid profile (%) of Basil different basil frying oil samples

Number of frying				
Fatty acid	**F0**	**F10**	**F30**	**F50**
C12:0 (Lauric)	0.149	0.17	0.17	0.171
C14:0 (Myristic)	0.92	0.972	0.991	0.973
C16:0 (Palmitic)	39.405	39.862	38.772	38.682
C18:0 (Stearic)	3.972	4.12	4.421	4.552
C20:0 (Arachidic)	0.326	0.329	0.324	0.131
Sum of SFA	44.772	45.453	44.678	44.509
C16:1n7 (Palmitoleic)	0.216	0.202	0.604	0.759
C18:1n9 (Oleic)	41.139	41.526	40.757	41.166
C18:1n7 (Vissinic)	1.087	0.971	0.967	1.259
C18:2n6 (Linoleic)	10.229	10.406	10.769	11.135
C18:3n3 (Linolenic)	0.165	0.174	0.231	0.288
Sum of USFA	52.836	53.279	53.328	54.607
Other Fatty Acids	2.392	1.268	1.994	0884

F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No.Frying at 30 times; F50: No.Frying at 50 times.

Fatty acids profile of various frying oil samples treated with rosemary extract and exposed to many frying times was given in Table (17). It could be easily seen that C16:0 (thepredominatone) did not affect till 10 times of frying then decreased till the end of experiment (50 times).

The C12:0 that came in the second or der with about 4% did not affect by frying times. On the other hand, the total SFA behaved similar trend that found in case of C16:0 fatty acid.

Regarding to USFA, C18:1n9 (about 41%) was minized to be about 36% after 30 and 50 times of frying. Meanwhile, the C18:2n6 (the second main unsaturated fatty acid) was continuously decreased by increasing frying times.

The total unsaturated fatty acids was approximately not affect till 30 times of frying them increased at 50 times of frying.

Table (13): Fatty acid profile (%) of different rosemary frying oil samples

Number of frying				
Fatty acid	**F0**	**F10**	**F30**	**F50**
C12:0 (Lauric)	0.189	0.221	0.164	0.727
C14:0 (Myristic)	1.034	0.932	0.854	0.815
C16:0 (Palmitic)	39.577	40.285	36.01	35.577
C18:0 (Stearic)	4.149	3.989	3.587	3.644
C20:0 (Arachidic)	0.376	0.336	0.111	0.111
Sum of SFA	45.325	45.763	40.726	40.874
C16:1n7 (Palmitoleic)	0.227	0.145	5.116	4.35
C18:1n9 (Oleic)	41.85	41.283	36.187	36.852
C18:1n7 (Vissinic)	0.901	1.139	0.786	0.77
C18:2n6 (Linoleic)	10.335	9.451	7.878	4.16
C18:3n3 (Linolenic)	0	0.154	1.028	9.167
Sum of USFA	53.313	52.172	50.995	55.299
Other Fatty Acids	1.362	2.065	8.279	3.827

F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No. Frying at 30 times; F50: No. Frying at 50 times.

Use of sage as natural antioxidant for prying oil samples and its beahviour throughout 50 times of frying was followed and recoded in Table (13). No changes were detected in fatty acids profile saturated or unsaturated one showing sage as a good natural antioxidant that could be use in fyring processes.

Table (14): Fatty acid profile (%) of different sage frying oil samples

Number of frying

Fatty acid	F0	F10	F30	F50
C12:0 (Lauric)	0.223	0.238	0	0
C14:0 (Myristic)	0.978	1.01	0.987	0.892
C16:0 (Palmitic)	40.93	40.529	40.535	39.476
C18:0 (Stearic)	4.012	4.083	4.297	4.361
C20:0 (Arachidic)	0.324	0.231	0.379	0.392
Sum of SFA	46.467	46.091	46.198	45.121
C16:1n7 (Palmitoleic)	0.256	0.886	0.336	0.557
C18:1n9 (Oleic)	41.975	41.718	41,359	40.03
C18:1n7 (Vissinic)	1.14	0.886	0.856	1.152
C18:2n6 (Linoleic)	9.924	9.897	10.117	10.861
C18:3n3 (Linolenic)	0.173	0.179	0.09	0.164
Sum of USFA	53.468	53.006	52.758	52.764
Other Fatty Acids	0.065	0.903	1.044	2.115

F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No. Frying at 30 times; F50: No. Frying at 50 times.

As expected, otherwise normally use of BHT as artificial antioxidant no changes were detected in fatty acid profile (saturated or unsaturated ones) owing to number of fryings as seen in Table (20)

Table (15): Fatty acid profile (%) of different BHT frying oil samples

Number of frying				
Fatty acid	**F0**	**F10**	**F30**	**F50**
C12:0 (Lauric)	0.151	0.158	0.157	0.148
C14:0 (Myristic)	0.94	0.971	0.951	0.88
C16:0 (Palmitic)	40.251	40.329	38.53	38.15
C18:0 (Stearic)	4.165	4.211	4.431	4.464
C20:0 (Arachidic)	0.324	0.361	0.325	0.131
Sum of SFA	45.831	46,03	44.394	43.955
C16:1n7 (Palmitoleic)	0.316	0.265	0.702	0.838

C18:1n9 (Oleic)	41.542	41.596	41.302	41.604
C18:1n7 (Vissinic)	1.196	0.92	1.033	1.295
C18:2n6 (Linoleic)	10.307	10.026	10.605	10.982
C18:3n3 (Linolenic)	0.185	0.206	0.154	0.127
Sum of USFA	53.456	53.013	53.796	54.846
Other Fatty Acids	0.713	0.957	1.81	1.199

F0: Not Frying at Zero Time; F10: No. Frying at 10 times; F30: No. Frying at 30 times; F50: No. Frying at 50 times.

4.10. Organolyptic evaluation:

Data given in Table (16)showed mean value of organolytpic evalaution of crispy potatoes that used artificial and natural antioxidants with different frying periods. No significant differences were detected between treatments as affected by using natural (Sage rosemary and base) and or artificial antioxidant (BHT). Such finding was noticed in all organolyptially evaluated parameters, i.e. appearance, odor, color, taste, texture and overall acceptability as seen in Table (17). Mean values were between 6.33-8.33.

In addition, oil samples were also organolyptically evaluated and its statistical analysis was given in Table (21). From these data it could be seen no significant difference were detected in various characteristics of frying oil used in this study. Such charachteristics are appearance, odor, color, viscosity and overall acceptability with the mean values ranged between 5.00 -8.67.

It could be concluded that using antioxidant either natural or artificial one did not organaloptically effect by type of antioxidant when the product or used oil were considered.

Table (16): Organoleptic evaluation of oil according to use artificial and natural antioxidant with different frying period.

Treatments	Appearance	Odor	Color	Viscosity	Overall acceptability
	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.	Mean ±S.D.

Control	8.33a±0.6	7.00b±0.0	8.33b±0.6	8.67a±0.6	8.33a±0.6
T1	7.67b±0.6	8.00a±1.0	9.00a±0.0	8.67a ±0.6	8.67a±0.6
T2	7.33b±0.6	8.00a±1.0	7.00c±0.0	7.67c±0.6	7.67b±0.6
T3	5.67c±0.6	5.00c±0.0	5.67d±0.6	7.33c±0.6	7.00c±1.0
T4	8.00a±0.0	7.00b±0.0	6.33d±0.6	8.00b±1.0	6.67c±0.6
LSD (0.05)	0.49	1.41	0.81	1.24	1.24

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

Table (17): Organoleptic evaluation of crispy potatoes according to use artificial and natural antioxidants with different frying period.

Treatments	**Appearance**	**Odor**	**Color**	**Taste**	**Texture**	**Overall acceptability**
	Mean ±S.D.	**Mean ±S.D.**	**Mean ±S.D.**	**Mean ±S.D.**	**Mean ±S.D.**	**Mean ±S.D.**
Control	8.33a±0.6	8.00a±1.0	7.00b±0.0	8.33a±0.6	8.33a±0.6	8.00b±0.0
T1	8.00a±1.0	8.00a±0.0	8.00a±1.0	8.00a±0.0	7.33b±0.6	7.67a±0.6
T2	7.67a±2.2	7.00b±1.0	7.33b±0.6	7.00b±1.0	7.00b±0.0	7.33b±0.6
T3	6.33c±0.6	6.33c±0.6	7.00b±1.0	7.33b±0.6	6.67b±0.6	6.67b±0.6
F4	7.33b±0.6	7.67a±1.1	7.33b±0.6	7.33b±0.6	7.00b±0.0	7.33b±0.6
LSD(0.05)	**1.24**	**1.56**	**1.33**	**1.15**	**0.81**	**0.49**

Each value in the table was obtained by calculating the mean of the three experiments ±S.D. The mean difference is significant at the 0.05 level.

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تأثير اضافة بعض الزيوت النباتية العطرية على اكسدة زيوت التحمير

د. جيهان ابراهيم واخرون

قسم الاقتصاد المنزلى – كلية التربية النوعية – جامعة عين شمس

الملخص:

أجريت هذه الدراسة لتحقيق الأهداف التالية:

١- دراسة علاقة الوقت ودرجة الحرارة أثناء عمليات القلي المصممة من خلال بروتوكول محدد.

٢- دراسة تأثير عملية القلي على مقاييس جودة زيت القلي المستخدم.

- مقارنة استخدام مضادات الأكسدة الطبيعية والصناعية على جودة الزيت أثناء عمليات القلي المختلفة.

٥- دراسة تأثير إضافة مضادات الأكسدة الطبيعية على جودة الزيت أثناء عمليا القلي المختلفة.

وكانت المعاملات المقترحة في هذه الدراسة هي كالتالي:

- معاملة الكنترول (أولين النخيل بدون إضافات).

- معاملة 1 (T1) أولين النخيل + 0.2% مستخلص نبات الروزماري (حصا البان).

- معاملة 2 (T2) أولين النخيل + 0.2% مستخلص نبات الساج (المريمية).

- معاملة 3 (T3) أولين النخيل + 0.2% مستخلص نبات الريحان.

- معاملة 4 (T4) أولين النخيل + 0.02% بيوتيلاتيدهيدروكسي تولوين.

تجهيز أولين النخيل لعملية القلي:

تم تسخين أولين النخيل لدرجة 60° مئوي قبل إضافة مستخلصات كل من الروزماري أو الريحان أو المريمية (بنسبة 0.2%) ثم أجرت عملية تقليب دائرية لتأكيد اكتمال ذوبان هذه المستخلصات – واستخدمت المعاملة بدون أي إضافات كعينة ضابطة سالبة والمعاملة المضاف إليها بيوتيلاتيد هيدروكسي تولوين كعينة ضابطة موجبة.

نظام القلي:

تم تسخين عينات زيت القلي لدرجات القلي لمدة حوالي دقيقتين لرفع درجة الحرارة من 25 إلى 180° م أعقبها إضافة رقائق البطاطس بمعدل 400 جم في 5 لتر زيت قلي لمدة 2.5 دقيقة لاكتمال عملية القلي في مرحلاتها الأولى، ثم أجريت مرحلة القلي الثانية (التبريد والتسخين) بعد نصف دقيقة، وتم إضافة رقائق البطاطس بعد رفع درجة الحرارة مرة أخرى من 170 إلى 180° م.

وتم تكرار هذه العملية 10مرات في اليوم الأول وانتهت التجربة في اليوم الخامس بعد إجراء 50 عملية قلي وتم تسجيل النتائج عند وقت الصفر (60° م)، 10 ، 30 ، 50 مرة من مرات القلي وكان حجم عينة زيت القلي المأخوذة للتحليل هو 250 مل للتحليلات الكيماوية والطبيعية وعينة أخرى 250مل للتقييم البيولوجي.

ويمكن تلخيص النتائج المتحصل عليها كالتالي:

١- رقم البيروكسيد:

ازداد رقم البيروكسيد بعد عشر مرات قلي من 4.8 – 7.9 مليمكافئ $100/o_2$ كجم زيت بنسبة زيادة حوالي 64.6% بينما كانت نسبة الزيادة 19.88 ، 22.22 ، 20.41% عند استخدام الروزماري والمريمية والريحان على الترتيب، وكمحصلة عامة ظهر عدم قابلية مضاد الأكسدة الصناعي (BHT) أو مضادات الأكسدة الطبيعية (الروزماري والمريمية والريحان) في تثبيط تكوين البيروكسيد حتى بعد 10 مرات قلي. ومن ناحية أخرى قللت مضادات الأكسدة نسبة تكوين البيروكسيد من حوالي 65 إلى 20%- 22 وكان عدد مرات القلي ذو تأثير معنوي على رقم البيروكسيد في كل العينات وازداد رقم البيروكسيد بزيادة عدد مرات القلي حتى 50 مرة. وحدثت الزيادة في تكوين البيروكسيد بصورة كبيرة ودراماتيكية ما بين 10 – 30 مرة قلي بينما ي المرحلة ما بين 30 – 50 مرة قلي كان معدل تكوين البيروكسيد ثابتاً أو اقل.

٢- رقم الانسيدين:

تأثر رقم الانسيدين بصورة واضحة بعدد مرات القلي بحيث كان بصفة عامة مشابهاً في المعاملات T1 , T2 , T3 لما وجد ي عينة الكنترول.

وازداد رقم الانسيدين بـ 1.45 ضعفاً بعد 10 مرات قلي ثم ارتفع ليصل إلى 2 ضعفاً مقارنة بوقت صفر القلي ثم ارتفع ارتفاعاً مستمراً إلى 2.55 , 2.66 , 2.81 ضعفاً في المعاملات T1 , T2 , T3 على الترتيب وبالنسبة للمعاملة T4 فقد أمكن تمييز الارتفاع في رقم الانسيدين بصورة اكبر وكانت القيم المقابلة بعد 10 , 30 , 50 مرة من القلي هي , 2.15 , 3.00 1.60 ضعفاً لذلك يمكن القول أن استخدام مضاد الأكسدة الصناعي لا يمنع التأثير الضار لعدد مرات القلي في الزيت بالمقارنة باستخدام مضادات الأكسدة الطبيعية.

٣- رقم التوتوكس (الأكسدة الكلية):

تراوح رقم التوتوكس لأولين النخيل غير المسخن مع أو بدون مضادات أكسدة بين - 20.17 17.90 ولم يوجد أي اختلاف معنوي بين العينات كلها سواء المعاملة أو غير المعاملة بمضادات الأكسدة سواء الطبيعية أو الصناعية عند صفر مرات قلي.

وأدت إضافة مستخلصات الأعشاب الطبيعية (0.2%) ومضاد الأكسدة الصناعي إلى تقليل رقم التوتوكس ومعنوياً بعد 10 مرات قلي بمقدار 1.20 ضعفاً مقارنة بالكنترول بالنسبة لكل المعاملات والتي ظهرت بقيم اقل من الكنترول.

٤- الرقم اليودي:

لم يتأثر الرقم اليودي بنوع مضاد الأكسدة المستخدم وذلك في بداية عملية القلي بمعنى عدم وجود معنوية حيث تراوحت القيم بين 56 - 58، واستمر هذا الاتجاه حتى 10 مرات قلي ولكن بقيم اقل (49 - 51) بينما بعد 30 مرة قلي اختلفت المعاملات معنوياً وكذلك بعد 50 مرة قلي ولكن بدرجة أكثر تأثيراً.

٥- رقم حامض الثيوباربيتيوريك:

لم يتأثر رقم حامض الثيوباربيتيوريك بنوع مضاد الأكسدة المستخدم ولكن تأثر بعدد مرات القلي حيث ازداد بمقدار حوالي 2 ضعفاً بعد 10 مرات قلي لكل المعاملات وبلغت الزيادة 3 ضعفاً في كل المعاملات بعد 30 مرة قلي ثم ازدادت بصورة حادة لتصبح 4.5 ضعفاً بالمقارنة بقيمها الأولية.

٦- رقم الحموضة:

تناسب قيم رقم الحموضة طردياً مع عدد مرات القلي ولوحظ اختلاف معنوي بين المعاملات وسجلت المعاملة F_{50} أعلى قيمة رقم حموضة.

٧- اللزجة:

اثر عدد مرات القلي معنوياً في هذا المقياس (اللزوجة) وذلك في المعاملات T3 , T4 حيث بلغت 107.14 , 109.13 (سنتيبواز) على الترتيب بعد 50 مرة قلي في حين تراوحت بين 84.41 – 96.89 (سنتيبواز) في باقي المعاملات بعد نفس العدد من مرات القلي.

٨- رقم القطبية:

بصفة عامة اتضح انه كلما زاد عدد مرات القلي كلما ازداد رقم القطبية بمعنى وجود علاقة طردية بينهما في حين وجدت علاقة عكسية واضحة بالنسبة لنوع مضاد الأكسدة المستخدم (طبيعي أو صناعي) ولم تلاحظ هذه العلاقة العكسية المشار إليها في بداية عملية القلي ولكن لوحظ انخفاض مستمر بمعدلات مختلفة تعتمد على نوع المعاملة.

٩- التقييم الحسي:

لم توجد أي اختلافات معنوي بين المعاملات نتيجة استخدام مضادات الأكسدة سواء الطبيعية أو الصناعية وذالك بالنسبة لكل من المظهر والرائحة واللون والطعم والقوام والقبول العام حيث تراوح متوسط القيم بين 6.33 – 8.33 وذلك بالنسبة لرقائق البطاطس المقلية.

بالإضافة لذلك تم تقييم عينات زيت القلي حسياً ولم توجد اختلافات معنوية في جميع صفات الزيت (المظهر، الرائحة، اللون، اللزوجة، القبول العام) حيث تراوح متوسط القيم بين 5 – 8.67 أي أن استخدام مضاد الأكسدة سواء الطبيعي أو الصناعي لم يتأثر حسياً بنوع المضاد سواء بالنسبة للزيت أو المنتج المستخدم.

١٠- تركيب الأحماض الدهنية:

لوحظ انخفاض معنوي في الحمض الدهني $C_{18:2\ n6}$ تراوح بين 39% – 45 خلال معامل القلي حتى 50 مرة قلي واثر مستخلص الريحان المضاف في زيادة ثبات الزيت وأدى لحمايته من

التحطم خاصة بالنسبة للحامض $C_{18:2\ n6}$ حيث كانت القيم 10.406% , 10.769، 11.135 بعد 10 , 30 , 50 مرة قلي.

أما بالنسبة للروزماري فقد أدى لحماية الحمض أوميجا 3 من التحطم وكانت القيمة 9.167 خلال فترة التسخين الطويلة مما يعكس السلامة الصحية للروزماري بالمقارنة بالريحان والمريمية.

تركيب الأحماض الدهنية لعينات زيت القلي:

أولاً: عينة الكنترول:

كان الحمض $C_{16:0}$ هو الحمض الدهني السائد (23.806%) وازداد بعد 10 مرات قلي وحتى نهاية التجربة (50 مرة) ليصبح 37% وجاء الحمض الدهني C18:0 في المرتبة الثانية بنسبة ثابتة تقريباً (حوالي 4%).

والجدير بالذكر أن مجموع الأحماض الدهنية المشبعة قد تزايد باستمرار بتزايد عدد مرات القلي بدءاً من 10 مرات قلي ثم تزايد ببطء بتزايد مرات القلي.

وسلك الحمض الدهني غير المشبع $C_{18:2\ n6}$ في المرتبة الثانية 37.783% وتزايد حتى أصبح حوالي 43% – وجاء الحمض الدهني $C_{18:2\ n6}$ في المرتبة الثانية (25.033%) وانخفض انخفاضاً حاداً بما يفوق 50% من نسبته نتيجة زيادة عدد مرات القلي وظهر مجموع الأحماض الدهنية غير المشبعة منخفضاً بحوالي 9% بعد 10 مرات قلي ثم ظل ثابتاً حتى نهاية التجربة (50 مرة).

ثانياً: عينة الريحان:

كان الحمض $C_{16:0}$ هو السائد بنسبة حوالي 39% ولم يتأثر بعدد مرات القلي (حتى 50 مرة) – وجاء الحمض $C_{18:0}$ في المرتبة الثانية بقيم حوالي 4% وسلك نفس سلوك الحمض السابق ولم يتأثر مجموع الأحماض الدهنية المشبعة (حوالي 45%) بعدد مرات القلي مقارنة بالعينة الكنترول.

ومن ناحية أخرى ظهر الحمض $C_{18:1nq}$ كحمض دهني غير مشبع بصفة سائدة بنسبة 41% أما مجموع الأحماض الدهنية غير المشبعة فلم يتأثر بعدد مرات القلي.

ثالثاً: عينة الروزماري:

لم يتأثر الحمض الدهني السائد ($C_{16:0}$) بعدد مرات القلي حتى 10 مرات ثم بدا الانخفاض حتى نهاية التجربة (50 مرة) وجاء الحمض $C_{12:0}$ في المرتبة الثانية بنسبة 4% ولم يتأثر أيضاً وسلك مجموع الأحماض الدهنية المشبعة نفس السلوك الملحوظ في الحمض الدهني $C_{16:0}$ لم يتأثر مجموع الأحماض الدهنية غير المشبعة حتى 30 مرة قلي ثم تزايد بعد ذلك (50 مرة) وانخفض $C_{18:1n9}$ (41%) ليصبح 36% بعد 30 , 50 مرة قلي بينما تناقص الحمض $C_{18:2n6}$ تناقصاً مستمراً بزيادة عدد مرات القلي.

رابعاً: عينة المريمية:

لم يلاحظ تغيرات في تركيب الأحماض الدهنية المشبعة وغير المشبعة مظهره بذلك عشب المريمية كمضاد أكسدة طبيعي جيد يمكن استخدامه في عملية القلي.