

Quality of Deep Frying Oil as Affected By the Type of Foods and Total Frying-Use Time

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Abstract:

Some quality parameters included, free fatty acids, peroxide value, iodine value, fatty acid composition as well as degree of color darkening were evaluated for mixed vegetable oil during 16 hours at 180 C° of deep-frying process. Both of potato and chicken were used as frying materials for 10 and 15 min., respectively. The results indicated that, there were gradually increase of free fatty acids and decrease of iodine value with the two types of the used foods with increasing of deep frying process time. Peroxide value, recorded initially an increase, then decreased after 14 and 6 hours of frying process of potato and chicken, respectively. During the deep frying process, the total unsaturated fatty acid content of the used oil was decreased while the total saturated fatty acid content was increased. Darkening degree of the used oil color was increased by increasing the use-time of frying process with slightly high of color darkening in case of chicken compared to that of potato frying.

Keywords: Deep-frying oil, Quality parameters- Fatty acid composition- Color- Potato- Chicken.

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Introduction:

Fats and oils play important functional and sensory roles in fried food products. However, deep fat frying process is an important operation used by food industry and consumers (Varela, 1988). It can be defined as a process of cooking food by immersing them in edible oil at a temperature about 120 to 180 °C (Vitrac *et al.*, 2000) and Torezan, 2005). Frying is used in homes, restaurants, and various segments of food industry (Brooks, 1991). Today, numerous processed foods are deep-fried because of the unique flavor-texture combination imparted to the food (Varela, 1988), and preparing tasty foods that have soft and moist interior together with the crispy crust (Garcia *et al.*, 2001). In the presence of oxygen, moisture, elements and free radical, physicochemical reaction such as thermoxidation, hydrolysis, polymerization, isomerization or cyclization take place at high temperature of frying process, thus leading to the decomposition of frying oil as well as affecting the quality of oil and frying product (Andrikopoulos *et al.*, 2002). Moreover deep frying process depend on several factors such as replacement with fresh oil, frying condition, original quality of frying oil, food material, type of fryer and frying temperature (Sanchez-Muniz *et al.*, 1992). Usually many oils can be used for frying, e.g. palm oil, corn oil, cotton oil, soya oil, canola oil and sunflower oil (Valenzuela *et al.*, 2003). On other hand, several different oils many be blended to get a healthy oil mixture. In Egypt many people use mixed oils in frying process.

However, the quality of the oil used in the frying operation becomes part of the food we eat and is, of course the major factor in the quality and nutritional value of the food we eat (Rossell, 2001). Thus, the objective of this study was to evaluate the quality of mixed vegetable oil as affected by two types of food during 16 hours of deep frying process.

Materials and Methods:**Materials:**

Refined mixed oil of sunflower, cotton seed and soya been, “Marmar” produced by Nile oil and Detergent Company was purchased from Bany qurra vilage. Potatoes and chicken were obtained from local market of Assiut city.

Sample preparation:

Fresh potatoes were peeled and sliced to a thickness of 1.5 cm. and 7 cm. in length using a mechanical slicer. Fresh chicken pieces were cut to about 200 gram in weight using a knife. The Batches of chicken scrupulously washed and cleaned.

Frying process:

The potato slices and raw chicken pieces were deep-fried independently, each in 1.5 Liter of refined mixed oil. When the oil temperature reached 180 °C, The potato slices and chicken pieces were fried for 10 and 15 min. intervals respectively until 16 hours. At the end of each 2 hours, 100 ml of the oil was taken from the fryer and analyzed for its physicochemical parameters.

Chemical analysis:

Acid value was determined according to the A.O.A.C. (2000) as follows: A known weight (10 g) of the oil was dissolved in a neutral ethyl alcohol (50 ml). The mixture was boiled on a water bath for 2 min and then titrated with potassium hydroxide solution (0.1 N) in the presence of phenolphthalein as an indica-

tor. Acid value is expressed as mg KOH required to neutralize the acidity in one gram oil.

The peroxide value was determined according to A.O.A.C. (2000). A known weight of the oil sample (1 g) was dissolved in a mixture consisting of glacial acetic acid: chloroform (10 ml, 3:2, v/v) then freshly prepared saturated potassium iodide solution (1 ml) was added followed by distilled water (30 ml) and then titrated slowly with sodium thiosulphate solution (0.01 N) in the presence of starch solution (1%) as an indicator. Peroxide value is expressed as milliequivalent peroxides/1kg oil.

The iodine value was determined using the Hanus method as described in A.O.A.C. (2000). A known weight of oil (0.25-0.5 g) was dissolved in chloroform (10 ml), then Hanus iodine ($I_2+Br / ACOH$) solution (25 ml) was added and left in the dark for 30 min. Potassium iodide solution (10 ml, 15%) was added followed by freshly distilled water (100 ml) and the excess iodine was titrated by sodium thiosulphate (0.1 N) until the yellow color of solution had almost disappeared. Titration was continued after adding few drops of starch as an indicator until the blue color had entirely disappeared. Iodine value is expressed as grams of I_2 absorbed by 100 g oil.

Fatty acid composition was methylated following the AOCS Official Method . The resulting fatty acid methyl esters (FAME) were analyzed on Trace GC Ultra gas chromatograph (Thermo Electron Corporation, Rodano, Italy) using a Trace TR-FAME fused silica capillary column (100 m 9 0.25 mm 9 0.25 μm ; ThermoFisher Scientific, Waltham, MA, USA). Hydrogen was used as the carrier gas with a flow rate of 1.5 mL min^{-1} . The column temperature was programmed from 70 to 160 C at 25 C min^{-1} and held for 30 min, and further programmed to 210 C at 3 C min^{-1} . Starting and final temperatures were held for 5 and 30 min, respectively. Split less injection was made using a PTV injector. Detector temperature was set at 250C. FAME samples, 1 μL , were injected with an AS 3000 autosampler (Thermo Electron Corporation, Rodano, Italy). Fatty acids were identified by comparison of retention time with authentic standards.

The color: Frozen oil samples were melted by placing them at 60°C in an oven until completely melts. The liquid samples were placed into 1 inch cell and using a Lovibond Tintometer Model E (Salisbury, England) the color was determined at 30°C by achieving the best possible match with the standard color slides of red, yellow and blue indices (PORIM, 1995).

Results and Discussion:

Changes in free fatty acids

Data indicated the changes in free fatty acids (FFAs) of the used oil are shown in Table (1) and Fig. (1). With increasing of deep frying process time, there were gradually increase of free fatty acids with the two types of fried foods. The increase of acid value may be due to hydrolysis of the oil. On other hand the free fatty acids of the used oil with chicken frying was slightly higher than that of potato case by the end of frying time and that may be due to some migration of chicken fat to the used oil, which was more unsaturation and faster to hydrolysis and oxidation. However, the free fatty values reached 0.57 and 0.66 mg KOH/g oil for potato and chicken frying, respectively after 16 hours of frying process. The increase in free acids value of frying oil during frying was also observed by

(Augustin *et al.*, 1987; Yoon *et al.*, 1987 and Zhang and Addis, 1990). Moreover, the maximum acid index of edible oils is 15mg KOH/g of oil as reported by (Krishnamurthy, 1982).

Table 1: Free fatty acids value of oil during deep frying of potato and chicken.

Time of frying (Hours)	Free fatty acids (mgKOH/g oil)	
	Potato	Chicken
0	0.193	0.193
2	0.196	0.195
4	0.216	0.235
6	0.296	0.276
8	0.314	0.353
10	0.377	0.392
12	0.396	0.465
14	0.487	0.552
16	0.572	0.662

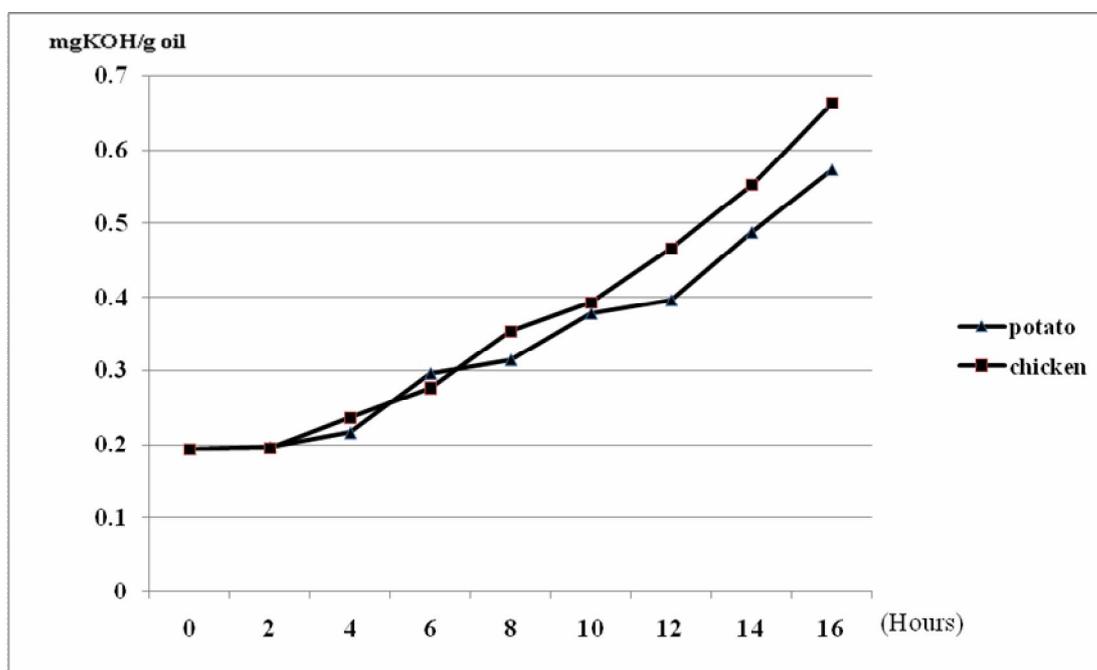


Fig. 1: Changes in free fatty acids of oil during deep frying of potato and chicken

Changes in peroxide value (PV):

Data presented in Table (2) and Fig. (2) revealed the changes of peroxide value of the used oil after 16 hours of frying of potato and chicken. Initially, there were an increase of peroxide values, then decreased after 14 hours in case

of potato and after 6 hours in case of chicken as shown in Table (2). As reported by (Weiss, 1970; Davidek *et al.*, 1990), the peroxides are unstable and will destruct to other secondary products. Decomposition of the peroxides to produce carbonyl and aldehydeic compounds under deep-fat frying operation is one of the reasons why peroxide value decreased (Chu *et al.*, 2001). However, during frying, the changes in peroxide value not related to the duration of frying, but were dependent pn the rate of formation and breakdown of oxidation products. Furthermore, frying of chicken with aldehydes (products of lipid oxidation) will increase Millard reactions and Strecker degradation, so peroxides, being a lipid oxidation product, will not be calculated for in the peroxide value of the oil (Davidek *et al.*, 1990).

Table 2: Peroxide value of oil during deep frying of potato and chicken.

Time of frying (Hours)	Peroxide value (meq/Kg oil	
	Potato	Chicken
0	3.933	3.933
2	4.127	4.230
4	4.90	4.960
6	5.357	5.240
8	4.947	4.943
10	5.923	4.557
12	6.863	4.140
14	7.157	3.853
16	6.340	3.243

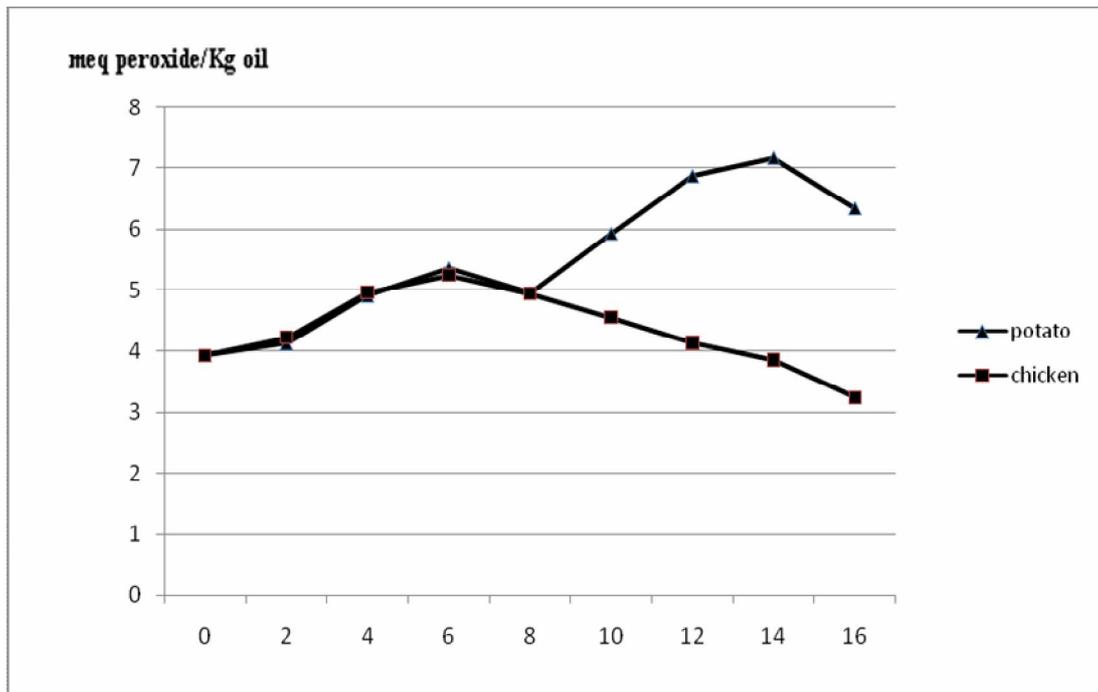


Fig. 2: Changes in peroxide value of oil during deep frying of potato and chicken.

Changes in iodine value (IV):

The changes of iodine value in the used oil are presented in Fig. (3). The iodine value was decreased from about 125 gI₂/100 g oil to about 115 and 110 gI₂/100 g oil for the oil used with deep frying of potato and chicken, respectively. The decrease of iodine value can be attributed to the destruction of double bonds by oxidation and polymerization (Chu *et al.*, 2001). Moreover, Iskander, (1992), reported that, the decrease in iodine value during frying could be attributed to the formation of fatty acids which varies in their degree of unsaturation or to the distribution of the double bonds in the oil. However, the decrease of iodine value of the oil used for chicken frying was faster than that of potato frying as shown in Fig. (3) and that could be due to the difference in the constituent of the two products. Chicken product has more fat content than potato and the fat of chicken is more unsaturation. During frying process, some of chicken fat migrate to the oil (Mountney, 1976). Moreover, during the frying, permeable unsaturated fatty acids are rapidly oxidized to saturated fatty acids, leading to a faster decrease in iodine value (Mazza and Qi, 1992).

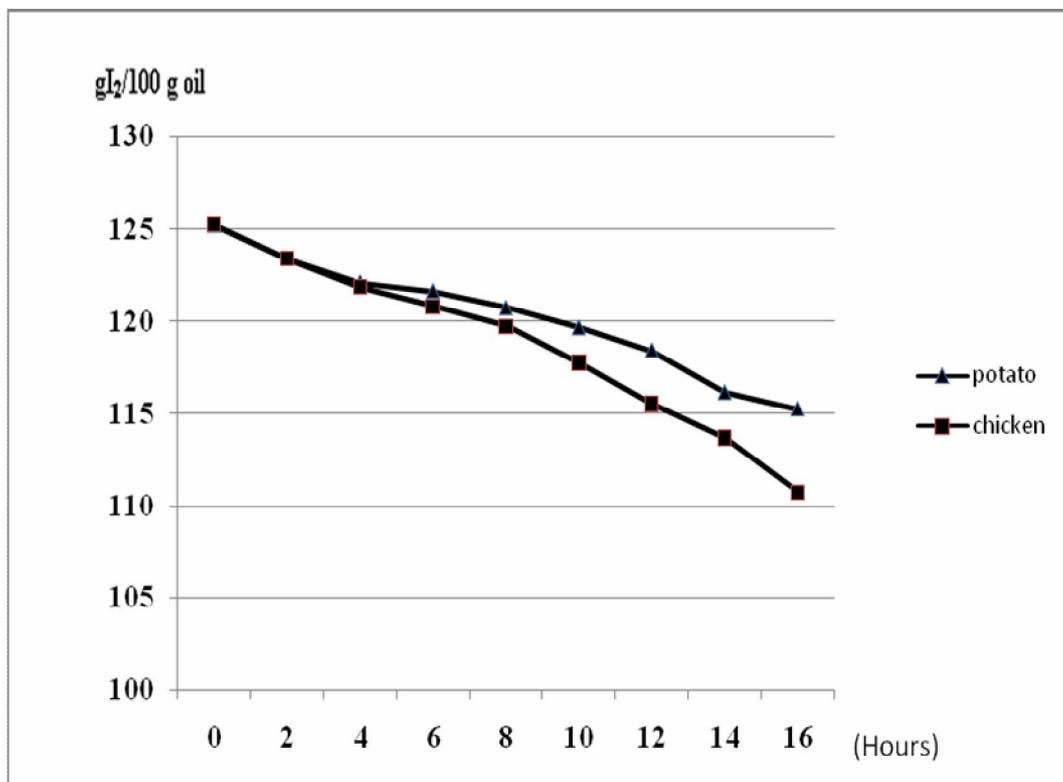


Fig. 3: Changes in iodine value of oil during deep frying of potato and chicken.

Changes in fatty acid composition:

The changes in fatty acid composition during deep-fat frying of potato and chicken are shown in Table (3) and (4), respectively. The most prominent fatty acids in the used oil were linoleic acid (55.3), oleic acid (22.7), palmitic acid (10.4), linolenic acid (5.2) and stearic acid (4.4%) of total fatty acids. The total saturated fatty acids constituted about 15.9%, while total unsaturated fatty acids recorded about 84.2% of total fatty acids content.

During frying of potato and chicken, there was a decrease in both of the linolenic acid and linoleic acid contents in accordance with (Sulieman *et al*, 2006 and Alireza *et al*, 2010), whereas the palmitic acid content was increased with a prolonged frying time same as observed by Alireza *et al*, 2010. Data in Table (3) and (4) revealed that, with increase of frying time, total saturated fatty acids content was increased, while total unsaturated fatty acids content was decreased. Arroyo *et al.*, (1995) pointed out that heat treatment of fats induce modification of fatty acids with two or three double bonds. However, the decrease of unsaturated fatty acids content reflects the decrease of iodine value by increasing frying time as shown in Fig. (3).

Table 3: Changes of fatty acids composition (% of total fatty acids) of the used oil during frying of potato.

Fatty acids	Carbond chain	Frying time (hours)				
		Control	4 hrs	8 hrs	12hrs	16hrs
Myristic acid	C14:0	0.099	0.093	0.689	0.499	0.603
Palmtic acid	C16:0	10.371	10.555	11.773	10.939	11.579
Plamitoleic acid	C16:1	0.825	0.723	0.295	0.203	0.106
Margaric acid	C17:0	0.143	0.275	0.624	0.719	0.831
Stearic acid	C18:0	4.36	6.569	6.487	6.859	7.347
Oleic acid	C18:1	22.663	22.374	21.197	21.622	21.109
Linoleic acid	C18:2	55.305	53.001	52.702	53.271	53.105
Linolenic acid	C18:3	5.218	5.299	5.217	4.868	4.222
Arachidic acid	C20:0	0.36	0.38	0.32	0.36	0.34
Gadoleic acid	C20:1	0.196	0.174	0.105	0.104	0.107
Behenic acid	C22:0	0.399	0.447	0.488	0.473	0.484
Lignoceric acid	C24:0	0.121	0.141	0.149	0.152	0.172
Total Sat. FA		15.853	18.86	21.479	19.501	20.356
Total Unsat. FA		84.207	81.14	78.521	80.499	79.644

Table 4: Changes of fatty acids composition (% of total fatty acids) of the used oil during frying of chicken.

Fatty acids	Carbond chain	Frying time (hours)				
		Control	4 hrs	8 hrs	12hrs	16hrs
Myristic acid	C14:0	0.099	0.115	0.108	0.133	0.113
Palmtic acid	C16:0	10.371	11.443	11.057	11.755	11.085
Plamitoleic acid	C16:1	0.825	0.626	0.55	0.395	0.308
Margaric acid	C17:0	0.143	0.372	0.081	0.076	0.241
Stearic acid	C18:0	4.36	5.055	6.316	6.758	7.817
Oleic acid	C18:1	22.663	21.917	21.545	21.49	21.092
Linoleic acid	C18:2	55.305	53.913	54.311	53.396	53.513
Unknown		0.121	0.461	0.056	0.0587	0.066
Linolenic acid	C18:3	5.218	5.157	5.04	4.974	4.85
Arachidic acid	C20:0	0.36	0.342	0.347	0.365	0.352
Gadoleic acid	C20:1	0.196	0.178	0.167	0.182	0.179
Behenic acid	C22:0	0.399	0.429	0.422	0.419	0.442
Total Sat. FA		15.732	17.756	18.331	19.506	20.05
Total Unsat. FA		84.207	81.791	81.613	80.437	79.942

Changes of oil color:

The changes of the used oil color during frying process are shown in Fig. (4). The color of the used oil was gradually darkened by increasing the frying time. Darkening of the oil may be due to leaching of pigments from the food into the oil (Singh, et al. 1996); a Maillard reactions, leading to the formation of brown pigment and increase absorption of blue light by conjugated double bonds, giving orange and brown colors to the oil (Kress-Rogers, et al. 1990) and an increase in polymer content (Moreira, et al. 1996). Darkening degree of the oil used for chicken frying was slightly high compared to that of potato frying (Fig. 4). The high degree of darkening in case of chicken could probably be attributed to the higher degree of Maillard browning in chicken. Further, particles from chicken pieces could have become charred to produce some fat-soluble colored compounds, which darkened the oil. However, the color index of vegetable oils increased with frying time, as a result of brown pigments from the fried products dissolving into the frying oil and a combined effect of oxidation and polymerization of unsaturated fatty acids in frying medium (Irwandi *et al.* 2000).

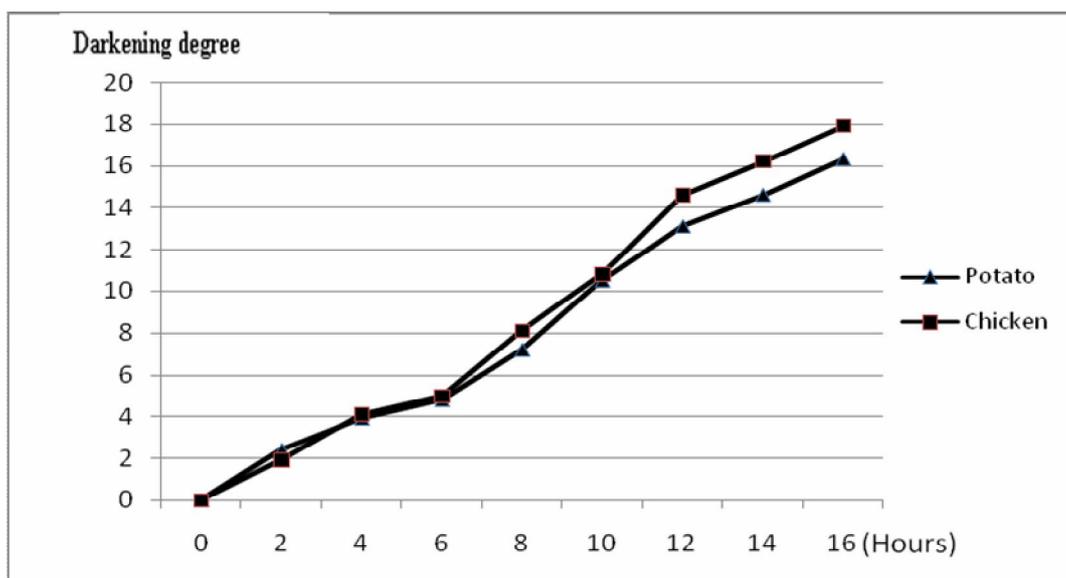


Fig. 4: Changes in color of oil during deep frying of potato and chicken.

Conclusion :

Some deterioration of the oil quality properties accrued by deep frying process and the type of fried food as well as a long of time-use are necessary factors in this side

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جودة زيت التخمير العميق ومدى تأثيره بنوعية الطعام وطول فترة الأستخدام

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الملخص:

تم تقييم بعض عناصر الجودة (رقم الحامض، رقم البيروكسيد، الرقم اليودي، تركيب الأحماض الدهنية بالإضافة الي درجة أعمقاق اللون) لزيت نباتي خليط خلال ١٦ ساعة من التخمير العميق علي ١٨٠ م°. واستخدمت شرائح البطاطس وقطع الدجاج لمدة ١٠ و ١٥ دقيقة علي الترتيب في عملية التخمير. أوضحت النتائج أن هناك زيادة تدريجية في رقم الحامض وانخفاض في الرقم اليودي للزيت بزيادة فترة استخدام الزيت مع كلا النوعين من الطعام. وسجل رقم البيروكسيد ارتفاعا في الزيت مع بداية عملية التخمير ثم انخفض بعد ١٤ و ٦ ساعات من تخمير البطاطس والدجاج علي الترتيب. وسجل محتوى الزيت انخفاضا في محتواه من مجموعة الأحماض الدهنية غير المشبعة مع زيادة في محتواه من الأحماض الدهنية المشبعة بزيادة فترة استخدامه في التخمير. كما زادت درجة أعمقاق لون الزيت المستخدم في التخمير بزيادة فترة الاستخدام مع زيادة طفيفة في درجة اغمقاق اللون في حالة تخمير الدجاج مقارنة بتخمير البطاطس.