Effect of Deep Frying on Fatty Acids Profile of Fried Chicken and Tilapia

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Abstract

The present study was designed to keep track of a real-life path to what happens in frying oil when meat is fried in it. It was designed to examine the fatty acid profile in the fried meat in random samples collected from Ismailia marketplace and other homemade. Generally, there were significantly difference ($P<0.05$) between the fried chicken samples of market and homemade for fatty acids (FA) content. The increased content of FA was toward the market samples. *trans*-9 elaidic acid, could not detected in homemade fried chicken. Repetitive use of oil at high temperature in the presence of wetness and air causes thermal degradation of oil. Deep fat frying (DFF) can lead to formation of trans fatty acids (TFAs).

Keywords: Trans fatty acid, Deep Fat Frying, Chicken, Tilapia.

Introduction

Chicken and fish meat are important sources for proteins which play several significant functions in the human body, including tissue growth and repair. They are considered as complete sources of high biological value protein, containing the nine essential amino acids that the body requires but cannot make for itself. The consumption habits of great sector of people have been heading toward ready-to-eat products due to changing of the life style in recent years. Consumers particularly the youth widely expend fast food as fried and roasted food as a result

of quick pace of life as well as children and teens prefer consumption of fried food in fast food restaurants throughout the world.

Frying is one of the oldest methods of food preparation. It is believed that it was used as early as 1600 bc by the ancient Egyptians ***(Sikorski & Kolakowska, 2010)***. Deep frying of chicken and fish not only responsible for good flavor and color but also generate many of hazardous compounds, such as TFA which are formed in food during frying in high temperatures. During frying, the presence of water and air in combination with other nutrient in the oil in high temperatures lead to some harmful reactions as thermal, hydrolytic and oxidative reactions and this reactions gave volatile and non-volatile compounds ***(Choe & Min, 2007)***.

TFA are unsaturated fatty acids which contain double bond (at least one), leading to a firmer molecule close to a saturated fatty acid. Trans-isomeric fatty acids originated from two sources natural source and synthetic source, the natural source of TFA is dairy and other animal fats due to biological hydrogenation in ruminant stomach and this gives the minimum dietary intake (2-8-%) while the main source of TFA is the synthetic hydrogenation (catalytic) of fats, and this gives 80-90% of the dietary intake ***(Mounts, 1979)***.

Trans fatty acids have significant health risks on human health, high consumption of TFA leads to increase the low-density lipoprotein (LDL) and decrease in the good lipoprotein which is the high-density lipoprotein (HDL) which resulting in coronary artery diseases (CAD). Due to this high ratio between the LDL: HDL increased the incidence of cardiovascular disease (CVD).

The present study was designed to keep track of a real-life path to what happens in frying oil (and to the food) when foods are fried in it. It was designed to examine the fatty acid profile in the fried meat in random samples collected from Ismailia marketplace and other homemade.

Materials and Methods

Collection of Market Fried samples:

Forty ready-for-serving fried meat meals samples, 20 each of Chicken fillet and tilapia fish were randomly collected from food serving establishment at Ismailia Province, Egypt. The collected samples were put in the freezer under -18ºC to freeze them and packed in a well isolated plastic bag. These samples labeled and prepared to be transferred into the Food

Science Laboratory in the Agriculture and Natural Resources-Missouri University, United States of America.

Preparation of Home Fried samples:

Forty raw meat samples, 20 each of Chicken Panée and fried tilapia fish were randomly collected from marketplace establishments at Columbia City, MO, USA. The fish samples prepared by the Egyptian recipe using marination spices and sauces which are 1 teaspoon salt, 2 teaspoons of each ingredient cumin spice crushed garlic cloves and vinegar immediately then battered by regular white flour and then fried in a deep hot vegetable oil used for the first time. While the chicken panee samples were purchased as raw fillet, battered by regular white flour and crumbling bread then fried in a deep hot vegetable oil used for the first time. The amount of oil in each treatment was just cover the fried food sample. The collected samples were put in the freezer under -18ºC to freeze them and packed in a well isolated plastic bags. These samples well labeled and prepared to be transferred into the Food Science Laboratory in the Agriculture and Natural Resources-Missouri University.

Sample Preparation and Fat Extraction *(Gruen, 2019):*

Samples (commercial products or wheat flour dough) were pulverized by a food processor and grinder (Hamilton Beach Fresh Grind (80335R) and weighed (5g) into a beaker. Each sample was spiked with an internal standard, Glycrel Tritridecanoate at concentration of 200µg/ml by adding 20ml of the stock solution (1mg/ml Dichloromethane). Then, the solvent of the glyceryl tritridecanoate (dichloromethane) was evaporated by applying nitrogen flow without any heat.

Afterward, approximately accurately 40 ml of chloroform, 20ml of methane and 12ml of deionized water into the spiked sample were added. Filtration of the mixture using vacuum applied to vacuum flask overlapped with Buchner funnel with Whatman #4 filter paper after homogenization of the mixture using hand mixer for 2 minutes (until complete grinding and homogenizing). The filtrate poured into a separator funnel and let to settle down for the separation between the upper level (methanol layer) and lower level (chloroform layer) which contain the fatty acids. The lower layer drained into 100ml volumetric flask and diluted to volume with chloroform.

Preparation of methyl esters and derivatization of the extraction *(Gruen, 2019):*

Before the derivatization, 1ml of the chloroform extraction

transferred to a screw cap test tube and evaporated by nitrogen flow without any heat using a Reacti-Vap Evaporator to remove the chloroform from the extract. The evaporated 1ml was treated with 7ml of derivatizing solution (Boron trifloride-methanol GC derivatization grade (~10% ~1.3M) after tightly closed till disappearing of fat globules and saponification was carried out at approximately 70ºC in Driblock DB-3H (Tecam) before GC/FID analysis.

After the test tube was cooled, 1ml of water and 1ml of hexane was added to the solution then was shaken very well to force the esters into the hexane layer. The hexane layer was transferred into another test tube which contained a pinch of sodium sulphate as a water scavenger to remove any residual water. The dried hexane transferred into labeled GC vial for analysis.

Gas Chromatography analysis:

The quantification of the whole profile of the fatty acid include Trans fatty acids levels in samples was performed using a GC/FID (Gas chromatography/Flame ignition detector) Agilent (7890B) equipped with a capillary column SP-2560 (Fused silica) Supelco (length 100m x I.D. 0.25mm x D.F. 0.25 mm) (Beliefonte, PA).

The oven temperature program was as follows: a 140ºC initial temperature was held for 5 min, increased to 180 ºC by a rate of 8ºC/min was held for 10min, then increased again to 210ºC by a rate of 4ºC/min and held for 10 min at this temperature, finally, the system was ended with 250ºC by a rate of 5ºC and held for 35 min. the inlet mode was split with a ratio 100:1. The injection block, detector and ion source temperatures were 250, 250, and 230ºC, respectively. The carrier gas (helium) flow through the column was 30 ml/min. The injection volume was 3 µl, and identification was determined using the Flame Ignition Detector (FID).

Statistical analysis:

Samples from three repetitions of frying at each temperature were collected and were analyzed in triplicate by SAS system (Statistical Analysis System). Data were analyzed by single factor analysis of variance (ANOVA). Statistically significant differences between means were determined by Duncan's multiple range tests. Statistically significant differences were determined at the $P<0.05$ levels as reported by ***(Snedecor & Cochran, 1994)***.

Discussion

Chicken and fish meat are the most nutritional values to human which giving them a high

biological value protein with different amount of vitamins and minerals. Cooking has great effect on these nutritional values either decrease or increase. One of the most cooking methods which famous all over the world is frying. The quality of fried meat depends not only on the type of meat and frying conditions, but also on the oil used for frying.

The result in table (1) revealed that relative content of fatty acids in the market and homemade fried chicken. The mean value of fatty acid in market fried chicken samples: lauric, myristic, palmitic, palmiteoleic, stearic, elaidic, oleic, linoleic, arachidonic, y-linolenic, α-linolenic, *cis*-11,14-eicosaenoic, and behanic acids were 0.1495, 0.7906, 48.3821, 1.8882, 14.8731, 0.1987, 79.7226, 0.7663, 0.7663, 0.2042, 3.9601, 0.1881 and 0.8867 mg/g respectively. Meanwhile for homemade fried chicken samples were 0.0063, 0.3029, 15.9531, 0.9601, 6.0005, 0, 147.7301, 58.0529, 1.1597, 0.7993, 12.5782, 0.0296 and 0.5526 mg/g respectively.

Generally, there were significantly difference ($P<0.05$) between the fried chicken samples of market and homemade for fatty acids content. The increased content of FA was toward the market samples. The continual or repeated use of oil at high temperature results in several oxidative, polymerization and thermal degradation reactions causing changes in its physical, chemical, dietary and sensory properties ***(Gloria & Aguilera, 1998).*** Chicken fats are mostly unsaturated and during frying, these will melt and seep out into the frying medium, where rapidly oxidized ***(Goburdhun et al., 2000)***

It is cleared that the TFA, *trans*-9 elaidic acid, could not detected in homemade fried chicken. Repetitive use of oil at high temperature in the presence of wetness and air causes thermal degradation of oil. DFF can lead to formation of TFAs and changes other chemical parameters like FFA, *PV*, An V and IV of the oil used. The extent of DFF can result in the formation of varied amounts of TFAs depending upon the frying temperature and the oil used ***(Romero et al., 2000, Liu et al., 2007).*** Such changes in overall FA profile of fried chicken may cause different adverse effects on human health.

Tilapia fish is commonly consumed in fried form by many households in Egypt. The result in table (2) revealed that relative content of FAs in the market and homemade fried tilapia and raw fish. The mean value of FA in market fried chicken samples: myristic, palmitic, palmiteoleic,

stearic, elaidic, oleic, linoleic, arachidonic, *cis*-11- eicosaenoic, α-linolenic, behanic, *cis*-5,8,11,14,17- eicosapentaenoic and *cis*- 4,7,10,13,14,17-docosahexanoic acids were 1.8878, 19.4488, 1.8878, 6.9827, 0.3473, 68.3979, 44.0784, 1.8180, 0.7315, 4.1587. 0.1356, 0.3915, 0.1111 and 0.7766 mg/g respectively. Meanwhile for homemade fried tilapia samples were 0.5377, 7.5244, 0.5377, 2.7362, 0.1949, 44.8649, 16.6384, 1.1781, 0.3767, 3.1029, 0.2325, 0.3635, 0.0839 and 0.5137 mg/g respectively. On the other hand, for raw tilapia sample were 0.4874, 4.8221, 0.3659, 2.1586, 0, 4.6168, 4.0349, under quantitation limit, under quantitation limit, 0, under quantitation limit, under quantitation limit, under quantitation limit and 0.2152 mg/g respectively.

There was significantly difference ($P < 0.05$) between the fried tilapia samples of market, homemade and raw fish for FAs content. As tilapia is one of low-fat content fish species, most of FAs were under quantitation limits in the current study. The FA profile of Nile tilapia fillets was affected by those of frying oils used. Results showed that the fat content of tilapia fillets were comparable after deep frying, irrespective of the cooking oil used ***(Jayasena et al., 2013)***

Trans-9 elaidic acid was undetected in raw tilapia sample. On the other hand, it was significantly decreased in homemade samples. Since frying oil was exposed continuously to high temperatures with the presence of atmospheric air and moisture of fish during the DFF process, many reactions including oxidation, hydrolysis, and polymerization could be occurred ***(Bangash & Khattak, 2006)***.The continuous using of frying oil might produce certain harmful toxic compounds to human health such as oxidized fatty acids, acrylamide, malonaldehyde, trans fatty acids, and polar compounds ***(Ganbi, 2011).***

The overall evaluation of this study concludes the importance of cumin and rosemary extracts as a natural antioxidant. Controlling the production of the most hazardous chemical compound from deep fat frying of meat and fish, trans fatty acids, is a time-temperature relationship with types of frying oils used in the current study.

The results of the study clearly advised consumers to depend on frying chicken in oil at 180ºC once at home whereas their total fatty acids will be rich in UFA than those obtained from the markets. In addition, it will be safe the consumers from the hazard of TFA. In concern to fried tilapia, also the homemade

fish is advisable because of their lower content of total fatty acids and high content of UFA in comparison with market samples. In addition, TFA was lower in homemade fried tilapia in comparison with market samples.

Results

Table (1): *Relative content of fatty acids in the market and homemade fried chicken.*

Fatty acids	Market samples		Homemade samples		P(T<=t)
	Mg/g*	%**	Mg/g*	%**	
Lauric acid (C12)	0.1495	0.0616[a]	0.0063	0.0034[b]	2.83E-11
Myristic acid (C14)	0.7906	0.3285[a]	0.3029	0.1273[b]	1.04E-11
Palmitic acid (C16)	48.3821	19.9808[a]	15.9531	6.8069[b]	6.64E-14
Palmitoleic acid (C16:1)	1.8882	0.7834[a]	0.9601	0.4108[b]	9.01E-08
Stearic acid (C18)	14.8731	6.2221[a]	6.0005	2.5508[b]	2.22E-05
Elaidic acid (C18:1n9t)	0.1987	0.0825[a]	0	0[b]	5.1E-17
Oleic acid (C18:1n9c)	79.7226	32.7494[a]	147.7301	58.9423[b]	2.27E-08
Linoleic acid (C18:2n6c)	0.7663	37.3286[a]	58.0529	24.7188[b]	3.6E-07
Arachidonic acid (C20)	0.7663	0.3161[a]	1.1597	0.4929[b]	0.00035
y-linolenic acid	0.2042	0.0843[a]	0.7993	0.3416[b]	1.26E-08
α-Linolenic acid (C18:3n3)	3.9601	1.6242[a]	12.5782	5.3523[b]	4.99E-09
***Cis*-11, 14-eicosadienoic acid methyl ester**	0.1881	0.0749[a]	0.0296	0.0125[b]	0.0022
Behanic acid (C22)	0.8867	0.3635[a]	0.5526	0.2403[b]	2.97E-05

The ranking of fatty acids in the table based on their appearance on the chromatograph sheet.

*The mean of the fatty acid amounts in the samples

Table (2): *Relative content of fatty acids in the market and homemade fried tilapia with their content in the raw tilapia.*

Fatty acids	Market Samples		Homemade samples		P (T<=t)	Raw tilapia relative %	
	Mg/g*	%**	Mg/g*	%**		Mg/g*	%**
Myristic acid (C14)	1.8878	0.6835[a]	0.5377	0.3716[b]	0.0117	0.4874	2.9186
Palmitic acid (C16)	19.4488	12.5011[a]	7.5244	9.6689[b]	0.0132	4.8221	28.8733
Palmitoleic acid (C16:1)	1.8878	1.1743[a]	0.5377	0.7199[b]	0.0157	0.3659	2.1912
Stearic acid (C18)	6.9827	4.4633[a]	2.7362	3.4313[b]	0.0178	2.1586	12.9252
Elaidic acid (C18:1n9t)	0.3473	0.2293[a]	0.1949	0.2567[b]	0.0483	NA	NA
Oleic acid (C18:1n9c)	68.3979	47.7511[a]	44.8649	57.0049[b]	0.0397	4.6168	27.6437
Linoleic acid (C18:2n6c)	44.0784	27.4465[a]	16.6384	21.0089[b]	0.0557	4.0349	24.1598
Arachidonic acid (C20)	1.8180	0.5105[a]	1.1781	0.4463[a]	0.3822	UQL	UQL
***Cis*-11-eicosenoic acid (C20:1n9)**	0.7315	1.2502[a]	0.3767	1.5261[b]	0.0149	UQL	UQL
α-Linolenic acid (C18:3n3)	4.1587	2.9945[a]	3.1029	3.99501[b]	0.0421	NA	NA
Behanic acid (C22)	0.1356	0.1079[a]	0.2325	0.2709[b]	0.0025	UQL	UQL
***Cis*-5,8,11,14-eicosatetraenoic**	0.3915	0.2821[a]	0.3635	0.4975[b]	0.0114	UQL	UQL
***Cis*-5,8,11,14,17-Eicosapentaenoic acid "EPA" (C20:5n3)**	0.1111	0.0788[a]	0.0839	0.0969[a]	0.5096	UQL	UQL
***Cis*-4,7,10,13,16,19-Docosahexanoic acid "DHA" (C22:6n3)**	0.7766	0.5281[a]	0.5137	0.7051[b]	0.0504	0.2152	1.2883

The ranking of fatty acids in the table based on their appearance on the chromatograph sheet.

*The mean of the fatty acid amounts in the samples

**Mean of the ratio of fatty acids to the total fat in the fish.

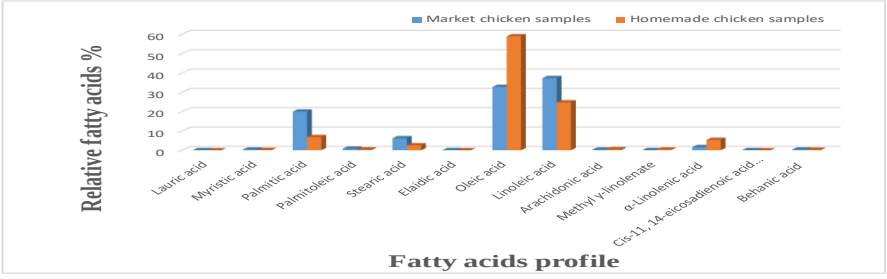

Fig. (1): *Fatty acids profile of market and homemade fried chicken*

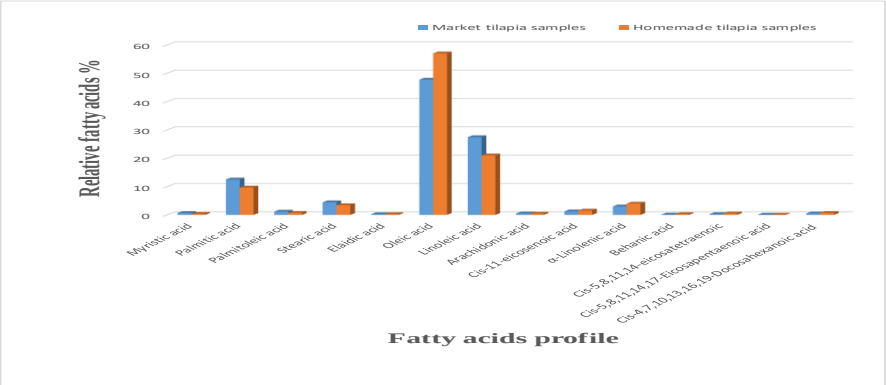

Fig. (2): *Fatty acids profile of market, homemade fried and raw tilapia*

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تأثير القلي العميق على بروفيل الأحماض الدهنية للدجاج والبلطي المقلي

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الملخص

يعتبر لحم الدجاج وسمك البلطي من المصادر الجيدة للبروتينات ذات القيم البيولوجية العالية التي تلعب العديد من الوظائف الهامة في جسم الإنسان. يعد القلي من أقدم طرق تحضير الطعام. ويعتقد أنه تم استخدامه في وقت مبكر من 1600 قبل الميلاد من قبل المصريين القدماء. لذلك تم تصميم الدراسة الحالية لتتبع مسار الحياة الواقعية لما يحدث في زيت القلي عند قلي اللحوم فيه من التغير في شكل الأحماض الدهنية في اللحوم المقلية. هذا وقد تم تجميع عينات لحم الدجاج وسمك البلطي المقلي عشوائيا من اسواق الإسماعيلية وتم تصنيع عينات مماثلة منزليا. أوضحت النتائج التي تم التوصل اليها بشكل عام أنه هناك دلالات احصائية معنوية كبيرة بين عينات الدجاج المقلية في السوق ومحتوى الأحماض الدهنية في العينات المصنعة منزليا. وكان محتوى الاحماض الدهنية متزايد تجاه العينات المجمعة من الاسواق. ولم تتمكن الدراسة من الكشف علي الاحماض الدهنية المتحولة في لحوم الدجاج المقلي منزليا. هذا واثبتت الدراسة انه قد يؤدي الاستخدام المتكرر للزيت عند درجة حرارة عالية في وجود الرطوبة والهواء إلى تدهور جودة الزيت مما ينعكس علي شكل الاحماض الدهنية وتكوين الاحماض الدهنية المتحولة مثل ما تم الكشف عليه في لحم سمك البلطي المقلي والتي قد تؤدي الي مخاطر صحية خطيرة علي صحة المستهلكين. وينصح بالاستخدام الزيت في عميلة قلي اللحوم لمدة مرة واحدة فقط عند درجة حرارة لا تزيد عن 180 درجة مئوية.