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THE EFFECT OF DEEP-FAT FRYING ON THE COMPOSITION OF FATTY ACIDS, FAT QUALITY INDICATORS AND OIL STABILITY OF SOME FRIED FOODS SERVED IN SOME EGYPTIAN HOTELS

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ABSTRACT

The present work was carried out to elucidate the nutritive quality of some fried foods served in Egyptian hotels in terms of their fatty acid composition and cholesterol content. Four samples of fried foods namely, potato, fish, meat and chicken were investigated in this respect. The aforementioned samples were collected from six hotels in Alexandria, Egypt to represent different hotel categories (5, 4 and 3 stars). The fatty acid composition revealed that the contents of unsaturated fatty acids were much higher than their counterpart saturated ones. This was true for all raw and fried samples under study. The ratios of saturated : monounsaturated : polyunsaturated fatty acids were as follows: potatoes (1.7 : 0.9 : 1), fish (0.6 : 1.02 : 1.0), meat (1.05 : 1.2 : 1.0) and chicken (0.9 : 1.09 : 1.0) after frying. Cholesterol content (mg/100g sample) of the fried foods investigated in the present work could be descendingly arranged as follows: chicken (173), meat (123), fish (158) and potato has no cholesterol respectively. Also sunflower oil consider the best as frying oil comparing with soya and cotton seed oil because it has low content from saturated and polyunsaturated fatty acids and high content from monounsaturated fatty acids. In attempt to increase sunflower oil stability and improvement the quality of some fried foods during frying, an aliquots from the concentrated ether extract of turmeric powder which containing curcumin as active natural antioxidant compound represent 500, 1000, 1500ppm as crude ether extract (polyphenols) were added to sunflower oil. Samples of sunflower oil mixed with curcumin were intermittent heated at 180 ± 5°C for 6 h/day and the heating process was repeated for 8 consecutive days. A control experiment was performed where butylated hydroxyl toluene (BHT) at 200ppm was added. Some chemical constants (acid, peroxide, iodine and thiobarbituric acid values) for the unheated and heated sunflower oil, vegetable and animal fried foods before and after deep-fat frying processes were determined and indicated that potato was more affected with frying than other samples and it has the highest acid, peroxide and TBA values. Also, the data indicated that the addition of curcumin to heated sunflower oil induced remarkable antoxidant activity and at 1500 ppm level was superior to that BHT in increasing sunflower oil stability. In most cases, statistical analysis explored a significant correlation between hotel category and the composition of fat absorbed by the food items investigation in the present study.

Keywords: fried foods, fatty acids, cholesterol, fish, meat, chicken, potato, curcumin, antioxidant, oil stability.

INTRODUCTION

With increasing health awareness and dietary recommendations, the general trend now is towards not only about the amount of fat in diet but also the type of fat. The frying of certain foods in oil on an industrial scale is common practice and an established food process.

The purpose of frying is to remove excess water, and gelatinize starch in the case of starchy products in order to cook the food (Moreira *et al.*, 1995).

Different vegetable oils differ in their suitability for deep frying and the suitability will also depend on the type of food to be fried (Frakas, 1994). The oils used in frying play dual functions, i.e., heating medium and enhance the formation of food flavour and it is worth to mention that the smoke point of oils to be used in frying should be not less than 215°C (Egan *et al.,* 1981).

Certain fried products containing high levels of saturated and/or trans fatty acids are now considered as undesirable and are becoming less popular. The main method of frying in the catering industry is deep fat frying. This method involve the use of a certain volume of fat so that the food can be totally immersed in it. In order to produce a top quality fried product, the temperature of the oil must be correctly set. This is because all frying processes are time-temperature dependent. Frying temperatures ranged from 165°C to 190°C. Although the food may look fried from outside, but it may still be insufficiently fried in the inside (Murphy *et al.,* 2001).

Respectively the effect of prolonged heating on the safety of frying oil has been established. Changes are primarily the result of hydrolytic and oxidative processes taking place during frying. Such changes include total polar compounds smell, taste, color, smoke point and acid value. (White, 1991). In addition, several other changes take place in fried foods, one of the most important changes occurring during heating is the formation of polymers, because unsaturated fatty acids are easily oxidized and may produce carcinogenic free radicals (Fritsch, 1981 & Perkins, 1996).

Oil oxidation is one of the major deteriorative reactions occurred during frying and induce a significant loss of quality. It is well known that oil oxidation leads to changes in functional, sensory and nutritive values as well as the safety of the fried food (Wu and Nawar, 1986). For these reasons antioxidants are added to oil and foods rich in lipids to inhibit the development of off-flavour arising from the oxidation of unsaturated fatty acids. However, the use of synthetic antioxidants such as butylated hydroxyl toluene (BHT) and butylated hydroxyl anisol (BHA) cause harmful effects on humans (Farag *et al.,* 2003). The use of natural antioxidants is highly desirable to replace the synthetic antioxidants. In this respect, the extracts of several plants have been reported to possess wide degrees of antioxidant activities (Evans and Reyhout, 1992 and Kim *et al.,* 1994).

In most developed countries, certain minimum quality standards for the oil in use are imposed initially, these standards are based on the level of oxidized fatty acids, they have now been replaced by the level of polar compounds with a limit of 25-30%, since they are too different to determine accurately (Melton *et al.*, 1994).

Most of nutritionists found that excessive levels of saturated fat in the diet can contribute to an increased risk of arteriosclerosis and other heart related problems .New Recommended Dietary Allowances have reduced the recommended daily calories from fat to 30% of total calories of which saturated fats should make up non more than one third the total (Stier, 1999), about 10% from monounsaturated fats, and no more than 10% from polyunsaturated fats. Some nutritionists also recommended that the consumption of omega-3-fatty acids, as a form of polyunsaturated fats, should be increased through an increased intake of high oily fishes like Salmon (Murphy *et al.*, 2001).

The present work was conducted to evaluate the fat composition and fat quality indicators of some fried foods offered by 3, 4, 5 star hotels in Alexandria, Egypt to increase sunflower oil stability for frying processes curcumin as a natural source for antioxidants was added to oil with different concentrations.

MATERIALS AND METHODS

Materials:

Twenty four samples of fried foods, offered for guests were collected from six different categories hotels in Alexandria, Egypt. The frying process was carried out under the prevailing conditions in the hotels under study.

These conditions can be summarized as follows:

1- All the hotels using the same instruments in all frying process (Electrical frier type). The recorded frying temperatures ranged from 60 to 175ºC for 15 minutes in potato, 20 minutes in meat and chicken and 13 minutes in fish.

2- Five and four star hotels cooked the food using pure sunflower oil whereas three star hotels use blended oil (i.e. cottonseed, soybean and sunflower oils).

3- All hotels obtained the raw materials from the same supplier company in Alexandria city. The most commonly animal foods used in the hotels are: legs of the veal, fish fillets, and breasts of chicken.

Methods:

1. Preparation of samples for analysis:

Raw and fried samples were minced and thoroughly blended using a blender (Moulinex, France). Samples were packed under nitrogen in polyethylene bags and stored in deep freezer at -18ºCfor analysis.

The following constituents were determined:

1.1. lipid extraction:

Total Lipids were extracted from each sample by the method of Folch *et al.* (1957), using a mixture of chloroform: methanol (2:1). Oil content was determined according to the procedure reported in A.O.A.C. (2000).

1.2. Fatty acid composition:

Portions from the extracted lipids were converted into their fatty acid methyl esters (FAME) according to the method of **Egan *et al.* (1981).** Fatty acid composition of the prepared samples was performed by Gas Liquid Chromatography (Schimadzu Gas chromatograph Model 4 CM, Kyoto, Japan) equipped with a Flame Ionization Detector (FID). A wide bore (id = 0.5 mm) chrome packed glass column was used (SP 2340 silica). The chromatographic conditions were as follows: Injection port temperature, 270°C, flame ionization detector (FID), 270°C initial oven temperature 150°C rising to 240°C at 5°C / min. The carrier gas used was nitrogen at flow rate of 25ml/min. Standard FAME (Nu - check -prep, Elyssia, MN, USA) were routinely chromatographed. The fatty acid composition of the samples was identified by comparison their retention time with the retention times of known standards

Saturated and unsaturated fatty acids were identified, and the ratio of TU/TS fatty acids was calculated.

1.3. Cholesterol content:

Cholesterol content of the raw and fried samples was determined according to the method of Searcy and Bergquist (1960).

1.4. Chemical analysis of raw samples:

Moisture. ash, lipids and crude proteins (N x 6.25) were determined according to A.O.A.C. (2000) methods.

Total hydrolysable carbohydrates was determined according to the method of **Dubois *et al.* (1956).**

1.5. Chemical constants of lipids:

Acid, peroxide and iodine values were determined according to A.O.A.C. (2000) methods. Thiobarbituric acid (TBA) was determined by the method reported by Tarladgis *et al.* (1966).

2. Sunflower oil:

Refined sunflower oil without antioxidant was obtained from local markets, acid and peroxide values for the oil were 0.38 and 4.89, respectively.

2.1. Preparation of turmeric crude ether extract:

Turmeric (*Curcuma longa*) seeds were obtained from Horticulture Research Institute, Agriculture Research Center, Cairo, Egypt. The seeds were ground to pass 1.0 mm.

Seeds powder was extracted with pet. ether (60 - 80°C) and the extract was concentrated using rotary evaporator.

2.2. Oil heating process:

Sunflower oil was placed in a stainless steel pan fryer and considered as a control. Portions of sunflower oil were mixed with aliquots of crude ether extract of turmeric (curcumin) to contain 1500ppm as crude ether extract. Also, an experiment was conducted where the oil was mixed with BHT at a concentration of 200ppm to compare the antioxidant efficiency of the phenolics of turmeric extract. The various oil samples were heated continuously on gas cooker at 180°C ± 5°C for 6 h every day. The heating process was reported for 8 consecutive days and stirred by hand every hour to ensure aeration and mixing. At certain periods of heating aliquots from the oil samples were removed and stored at 5°C for subsequent determinations.

2.3. Improvement of fat quality indicators of fried potato:

Potato was fried in sunflower oil with different concentration of curcumin 500, 1000, 1500ppm and 200ppm BHT at 175°C for 15 min.

Statistical analysis:

The data obtained from the present study were subjected to statistical analysis using standard deviation (S.D) according to the method described by Sendecor and Cochran (1980).

RESULTS AND DISCUSSION

1. Chemical composition of raw samples:

The chemical composition of the raw samples of fried foods collected from hotels of different categories were analysed and the obtained results are illustrated in Table (1).

Analysis of raw animal samples (fish, meat and chicken) shows that the levels of moisture, fat, crude proteins, ash, total hydrolysable carbohydrates and cholesterol content mg/100g sample were: 76.55, 1.13, 15.89, 0.51, 0.32 and 55.0mg/100g sample for fish samples and 70.20, 2.20, 21.10, 1.10, 0.20% and 65.9mg/100g sample for meat samples and 74.40, 1.86, 20.38, 1.0, 0.1 and 74.9mg/100g sample for chicken samples respectively based on fresh weight basis.

These data demonstrate that the main animals samples constituent was crude proteins. It was approximately 12 to 16 times as high as that of fat content. Ash content was about 0.5 – 0.8 times as great as that of fat content.

The animals samples contained the lowest amounts of total hydrolysable carbohydrates.

Analysis of potato samples (vegetable food) showed that the levels of moisture, fat crude proteins, ash, total hydrolysable carbohydrate and cholesterol content were 77.80%, 0.6, 1.3, 0.6, 17% and 0.0mg, respectively based on fresh weight. From these data it shows that the main constituent was the total hydrolysable carbohydrate (starch), low amount of fat, crude proteins, ash content and no cholesterol content.

These data are in harmony with those obtained by Nassar (2002) who found that crude protein, crude lipids and ash content in Bolti fish were 17.84, 1.41 and 0.61 and Prusa and Hughes (1986) who found that turkey breast muscle contain 72.8%, 25.3 and 1.5% from moisture, protein and lipid contents.

Table (1): Chemical composition of the examined raw samples (on fresh weight basis)

Constituents	Fish	Meat	Chicken	Potato
Moisture %	77.55 ± 3.81	72.20 ± 2.76	75.40 ± 4.23	77.80 ± 5.36
Fat %	1.17 ± 0.37	2.30 ± 0.15	1.86 ± 0.09	0.6 ± 0.01
Crude protein %	16.99 ± 0.92	22.10 ± 1.52	20.38 ± 2.03	1.3 ± 0.07
Ash %	0.71 ± 0.06	1.40 ± 0.09	1.00 ± 0.51	0.6 ± 0.003
Total hydrolysable carbohydrate %	0.52 ± 0.03	0.40 ± 0.007	0.10 ± 0.001	18.0 ± 1.01
Cholesterol content mg/100g sample	55.0 ± 1.87	65.9 ± 2.86	74.9 ± 4.42	0.0 ± 0.00

2. Fatty acid composition in different raw samples and frying sample:

Fatty acid from different raw samples of fish, meat, chicken and potato were separated, identified and the results are shown in Table (2). It could be observed that raw fish contained myristic acid and stearic acid as the most abundant saturated fatty acids but linoleic and linolenic acids were the major consitulens of unsaturated fatty acids. The ratio of (TU/TS) reached to 1.6, raw meat and chicken has a high amount of palmetic acid as a major saturated fatty acid and the most abundant unsaturated fatty acids were oleic and linoleic acid and the ratio of (TU/TS) were 1.6 and 2.4 respectively but in potato results showed that all fatty acids were found with low amount due to potato (starchy products) and these fatty acids may be come from semi fried sample.

These results are in agreement with Nassar (2002) who found that Bolti fish contain high amount from poly unsaturated fatty acids.

Table (2): Fatty acids composition of fat from raw samples.

Constitute fatty acid % w/w of total fatty acid	Fish	Meat	Chicken	Potato
Fatty acid composition				
Saturated fatty acid				
Lauric $C_{12:0}$	0.02	0.01	0.0	0.0
Myristic $C_{14:0}$	14.2	5.4	5.13	2.69
Palmetic $C_{16:0}$	4.79	24.46	18.80	5.62
Stearic $C_{18:0}$	8.45	5.29	3.8	0.65
Arachidic $C_{20:0}$	0.0	0.0	0.0	0.0
Total	27.46	35.16	27.73	8.96
Unsaturated fatty acid				
Myristoleic $C_{14:1}$	0.01	0.01	0.02	0.0
Palmitoleic $C_{16:1}$	8.96	2.61	4.06	2.1
Oleic $C_{18:1}$	2.70	20.70	24.06	7.17
Linolenic $C_{18:2}$	17.50	26.4	23.23	19.68
Linolenic $C_{18:3}$	14.54	5.64	15.95	7.5
Total	43.71	55.36	67.32	36.45
Other not detected	28.83	9.48	4.95	54.59
UNSAT / SAT ratio	1.6	1.6	2.4	4.1

Data in Table (3) indicated that sunflower oil consider the best as frying oil comparing with blended oil consist of (sunflower : soybean : cotton seed oil) because it has low content from saturated and polyunsaturated fatty acids and high content from monounsaturated fatty acids. These data are in harmony with those obtained by Echarte *et al.* (2001) who found that sunflower oil contain on linoleic acid with 57.32%, linolenic acid 8.31% and oleic acid 21.52%.

3. Fatty acid composition and cholesterol content in different fried foods:

Fatty acid composition and cholesterol content of fried foods are shown in Tables (4 – 8). From Table (8) it can be observed that fried potato contained palmetic acid as the most abundant saturated fatty acid (23.30%). The unsaturated fatty acids present in potato were linoleic (30.50%), oleic acid (16.80%) and palmitoleic acid (4.10%). The ratio of (TU / TS) reached 1.16. The data showed that fried potato as a vegetable food (starchy products) was free from cholesterol.

Dealing with the other three kinds of animal fried foods (fish, meat and chicken), the ratio of unsaturated fatty acids to saturated fatty acid was higher than that in fried potato. It was as high as 3 in fish and 2 in meat and chicken. In every case the unsaturated fatty acid / Saturated fatty acid ratio increased when the food was fried. The polyunsaturated fatty acids (PUFA) in meat and chicken amounted 32.0%, while in fish was 41.6%.

Table (3): Fatty acids composition of fried media (sunflower oil for five and four star hotels and blended oil for three star hotels).

Constitute Fatty acid % w/w of total fatty acid	Sunflower oil	Blended oil
Fatty acid composition		
Saturated fatty acid		
Myristic $C_{14:0}$	0.53	0.48
Palmetic $C_{16:0}$	18.12	12.16
Stearic $C_{18:0}$	9.50	13.75
Arachidic $C_{20:0}$	0.86	1.12
Total	29.01	27.51
Unsaturated fatty acid		
Palmitoleic $C_{16:1}$	2.40	0.11
Oleic $C_{18:1}$	33.16	21.52
Linolenic $C_{18:2}$	23.98	37.42
Linolenic $C_{18:3}$	5.11	8.22
Total	64.65	67.37
Other not detected	6.34	5.22
UNSAT / SAT ratio	2.2	2.4

Table (4): Fatty acids composition and cholesterol content of fat from fried fish collected from different hotels in Alexandria, Egypt

Constitute Fatty acid % w/w of total fatty acid	Hotels					
	5 star		4 star		3 star	
	A	B	C	D	E	F
I- Total lipids %	1.89	1.99	2.48	2.79	3.12	3.27
II- F.A. composition %						
Saturated fatty acid						
$C_{12:0}$	0.10	0.00	0.00	0.20	0.10	0.00
$C_{14:0}$	0.90	0.80	1.20	1.40	1.90	1.70
$C_{16:0}$	13.50	15.01	11.70	13.0	14.21	15.21
$C_{18:0}$	6.12	6.80	6.59	7.11	8.40	7.79
$C_{20:0}$	0.20	0.40	0.60	0.70	0.80	0.50
Total	20.82	23.01	20.09	22.41	25.41	25.20
Unsaturated fatty acid						
$C_{14:1}$	0.30	0.50	0.20	0.40	0.10	0.00
$C_{16:1}$	3.20	3.99	4.35	4.60	1.78	2.11
$C_{18:1}$	23.20	24.03	22.68	25.01	29.00	28.00
$C_{18:2}$	30.40	31.77	32.12	30.21	28.20	29.44
$C_{18:3}$	10.11	11.56	10.43	11.17	12.00	12.12
Total	67.21	71.85	69.78	71.39	71.08	71.67
Other non detected	11.97	5.14	10.13	6.2	3.51	3.13
UNSAT / SAT	3.23	3.12	3.47	3.18	2.80	2.84
III- Cholesterol (mg / 100g sample)	131.00	122.00	139.00	128.00	158.00	152.00

Table (5): Fatty acid composition and cholesterol content of fat from fried meat collected from different hotels in Alexandria, Egypt

Constitute Fatty acid % w/w of total fatty acid	Hotels					
	5 star		4 star		3 star	
	A	B	C	D	E	F
I- Total lipids %	3.30	3.50	3.90	4.10	5.00	4.88
II- F.A. composition %						
Saturated fatty acid						
$C_{12:0}$	0.30	0.00	0.00	0.20	0.70	0.60
$C_{14:0}$	2.10	2.20	3.00	2.30	3.00	3.20
$C_{16:0}$	23.60	24.00	25.20	24.66	25.50	25.03
$C_{18:0}$	4.20	4.60	5.70	4.22	5.70	6.20
$C_{20:0}$	0.05	0.00	0.10	0.07	1.00	0.66
Total	30.25	30.80	34.00	31.45	35.90	35.69
Unsaturated fatty acid						
$C_{14:1}$	1.20	1.10	1.00	1.40	0.62	0.44
$C_{16:1}$	4.40	4.50	3.99	4.87	3.20	2.60
$C_{18:1}$	24.30	25.90	26.10	23.12	27.13	27.60
$C_{18:2}$	29.70	27.10	26.80	28.00	24.60	23.18
$C_{18:3}$	4.28	5.29	5.21	5.99	6.28	7.12
Total	63.88	63.89	63.10	63.38	61.83	60.94
Other non detected	5.87	5.31	2.90	5.17	2.27	3.37
UNSAT / SAT	2.11	2.07	1.86	2.02	1.72	1.71
III- Cholesterol (mg / 100g sample)	86.78	93.90	107.10	100.20	110.12	123.30

Table (6): Fatty acid composition and cholesterol content of fat from fried chicken collected from different hotels in Alexandria, Egypt.

Constitute Fatty acid % w/w of total fatty acid	Hotels					
	5 star		4 star		3 star	
	A	B	C	D	E	F
I- Total lipids %	3.60	3.90	4.20	3.40	4.50	4.00
II- F.A. composition %						
Saturated fatty acid						
$C_{12:0}$	0.00	0.10	0.03	0.01	0.00	0.02
$C_{14:0}$	0.30	0.50	0.80	0.90	1.20	1.10
$C_{16:0}$	26.12	25.60	24.33	25.00	30.30	27.01
$C_{18:0}$	3.02	2.89	3.16	3.33	4.22	3.99
$C_{20:0}$	0.30	0.50	0.60	0.50	0.20	0.10
Total	29.74	29.59	28.92	29.74	35.92	32.22
Unsaturated fatty acid						
$C_{14:1}$	1.20	1.10	1.20	1.30	0.00	0.10
$C_{16:1}$	3.10	3.50	2.80	2.20	1.60	2.00
$C_{18:1}$	22.71	21.80	22.13	20.20	26.20	25.00
$C_{18:2}$	28.10	26.80	25.00	24.10	21.70	22.90
$C_{18:3}$	7.12	8.06	8.13	7.24	9.12	10.00
Total	62.23	61.26	59.26	54.84	58.62	60.00
Other non detected	8.03	9.15	11.82	15.4	5.46	7.78
UNSAT / SAT	2.09	2.07	2.05	1.84	1.63	1.86
III- Cholesterol (mg / 100g sample)	199.6	168.6	149.00	112.00	160.00	173.00

Table (7): Fatty acid composition and cholesterol content of fat from fried potato collected from different hotels in Alexandria, Egypt

Constitute Fatty acid % w/w of total fatty acid	Hotels					
	5 star		4 star		3 star	
	A	B	C	D	E	F
I- Total lipids %	31.0	2.89	3.30	3.00	4.99	4.01
II- F.A. composition %						
Saturated fatty acid						
$C_{12:0}$	0.10	0.00	0.00	0.10	0.00	0.00
$C_{14:0}$	19.56	17.12	18.29	20.54	16.33	16.00
$C_{16:0}$	21.44	22.12	25.43	20.30	25.16	27.00
$C_{18:0}$	2.60	3.00	2.80	2.00	3.30	4.30
$C_{20:0}$	0.20	0.50	0.40	0.40	0.40	0.30
Total	43.90	43.74	46.92	43.34	45.19	43.60
Unsaturated fatty acid						
$C_{14:1}$	0.50	0.60	0.40	0.30	0.10	0.30
$C_{16:1}$	4.50	3.90	2.00	5.56	3.00	3.50
$C_{18:1}$	16.40	17.01	18.40	14.20	15.90	19.21
$C_{18:2}$	29.72	30.16	29.80	32.50	30.00	30.90
$C_{18:3}$	0.64	0.52	0.55	0.80	0.80	0.99
Other non detected	4.34	4.07	1.93	3.30	5.01	1.50
Total	51.76	52.19	51.15	53.36	49.80	54.90
UNSAT / SAT	1.17	1.19	1.13	1.13	1.10	1.26
III- Cholesterol (mg / 100g sample)	0.00	0.00	0.00	0.00	0.00	0.00

Table (8): Means and standard deviation of fatty acids and cholesterol contents of fat from the fried foods.

Constitute Fatty acid % w/w of total fatty acid	Fish	Meat	Chicken	Potato
I- Total lipids	2.59	4.10	3.90	3.50
II- Fatty acid composition %				
Saturated fatty acid				
Lauric $C_{12:0}$	0.06	0.30	0.03	0.03
Myristic $C_{14:0}$	1.30	2.60	0.80	17.90
Palmetic $C_{16:0}$	13.80	24.70	26.40	23.60
Stearic $C_{18:0}$	7.10	5.10	3.40	3.00
Arachidic $C_{20:0}$	0.50	0.10	0.40	0.40
Total	22.80	33.00	31.00	45.10
Unsaturated fatty acid				
Myristoleic $C_{14:1}$	0.30	0.90	0.80	0.40
Palmitoleic $C_{16:1}$	3.30	3.90	2.50	4.10
Oleic $C_{18:1}$	25.30	25.70	23.00	16.80
Linoleic $C_{18:2}$	30.40	26.60	24.80	30.50
Linolenic $C_{18:3}$	11.20	5.70	ε.30	0.71
Total	70.50	62.80	58.50	52.50
Other non detected	6.70	4.20	10.50	2.40
UNSAT / SAT ratio	3.10	1.90	1.90	1.16
III- Cholesterol (mg / 100g sample)	138.33	103.56	160.36	0.00

The profile of unsaturated fatty acids in potato show that linoleic acid was the most predominant fatty acid (30.50%) followed by oleic acid (16.80) and palmitoleic acid (4.10%) in decreasing order but in fried meat, chicken and fish the most predominant unsaturated fatty acid was linoleic acid followed by oleic cid, linolenic acid and palmitoleic acid in decreasing order.

Changes in fatty acid profiles between different samples due to frying media such as fried in sunflower oil increased oleic and strearic acid contents in fried samples while frying in soybean oil produced a considerable decrease in the saturated fatty acids content (Sanchez-Muniz *et al.*, 1992).

The ratio of saturated: monounsaturated : polyunsaturated fatty acids in fried foods under study were found to be as follows: potato (1.7 : 0..9 : 1.0), fish (0.6 : 1.02 : 1.0), meat (1.05 : 1.20 : 1.0) and chicken (0.9 : 1.09 : 1.0).

These ratio were slightly different from that recommended by the American Heart Association which recommended of (1.0 : 1.0 : 1.0) for saturated : monounsaturated : polyunsaturated in oil composition (White, 1991).

The cholesterol content was as expected higher in fried chicken and meat (173 and 123 mg/100g sample, respectively) than raw samples (74.9 and 65.9 mg/100g sample). These due to during frying heat is transferred from the oil to the food, water is evaporated from the food and oil is observed by the food thus moisture content is decrease and cholesterol content is increased (Morecira *et al.*, 1995). The aforementioned data have a great importance when evaluating the nutritional value of hotel foods. It must be born in mined that balanced diet should contain in higher ratio of PUFA and lower amount of saturated fatty acids. In this respect, Al-Khalifa (1993) showed that PUFA / MUFA and one saturated fatty acid, stearic acid, lead to reduction in serum cholesterol level. Moreover, Helal (1999) recommended serving fish for heart patients as it includes (ω – 3) and (ω – 6) fatty acids which decrease cholesterol content.

The chemical composition of fat extracted from hotel fried foods is shown in Table (4 – 8). It could be observed that the ratio of TU / TS in fried potato was higher in hotel of three stars than in five stars. But in fried fish, meat and chicken the ratio of TU / TS were higher in hotel of five stars than that in the three stars. It may be supposed that the prevailing frying conditions in hotels under study, such as temperature, time, kind and quality of oil used and preceding fried foods in the same frying oil, one or more of these conditions may affect the unsaturated fatty acids content as well as TU / TS ratio.

The cholesterol content of fried meat, chicken and fish was higher in hotels of three stars than that in hotel four and five stars, respectively. it is well know that in the case of a longer heating time moisture content was decrease thus cholesterol content was increase.

4.Effect of deep-fat frying with sunflower oil on chemical characteristics of some hotels fried foods:

From the results of fatty acid profile of different fried foods and composition of oils which used in frying (Table, 3) we observed that sunflower oil consider the best as frying oil because it has low content from polyunsaturated fatty acids, saturated fatty acids and high content from monounsaturated fatty acids compared with soybean oil and cotton seed oil which has highest oxidation levels.

4.1- Changes in acid value:

The data in Tables (9, 10) indicate that acid values of raw samples (fish, meat chicken and potato) before frying process were 0.13, 0.26, 0.18 and 0.27 respectively and reached to 0.65, 0.96, 0.58 and 0.98 after frying with sunflower oil for 15 min for potato, 13 min for fish and 20 min for meat and chicken at 160-175°C these due to the free fatty acids produced during the lypolisis which is one of the processes that take place during the fat frying by the water content in raw samples. These results are in agreement with those obtained by Echarte *et al.* (2001) who reported that the free fatty acid was highly correlated with frying time.

4.2- Changes in peroxide value:

From the results in Table (9, 10) it could observed that the peroxide value increased from 3.89, 5.12, 4.64 and 5.97 before frying to 14.46, 16.98, 15.27 and 18.48, respectively after frying fish, meat, chicken and potato samples. These increases due to oxidation of sunflower oil by heating (160 – 175°C) during frying and produced free radicals which in turn rapidly react with atmospheric oxygen to produce hydroperoxides. In this respect Farag *et al.* (2003) showed that the oxidation was accelerated by raising the temperature.

4.3- Changes in thiobarbituric acid value:

Thiobarbituric acid (TBA) as mg malonaldhyde per kg lipid was determined for all samples before and after frying to study oxidation deterioration of food fats and the results are shown in Tables (9, 10) and indicated that TBA values were rabidly increased (from 0.420, 0.441, 0.450 and 0.482 to .730, 0.780, 0.760 and 0.819), respectively after frying process for fish, meat, chicken and potato samples. These fluctuation in TBA values of frying foods after frying could be due to breakdown and volatility of the oxidative compounds that are formed during frying.

4.4- Changes in iodine value:

The iodine value of raw and fried samples was determined and the results are shown in Tables (9, 10).

It could be observed that the iodine values of raw samples fish, meat, chicken and potato were 106.80, 102.60, 99.00 and 98.60, respectively. These differences in iodine value could be attributed to the differences in their content of the unsaturated fatty acids but the iodine values of fried foods were decreased after frying to 99.20, 94.16, 93.98 and 93.80, respectively.

The decreasing during frying in the iodine value could be due to polymerization and formation of trans and conjugated double bonds (Perkins, 1996).

From the obtained results in Table (9, 10) we conclude that the kind of oil either or the kind of food had a marked effect on the fat quality indicators (A.V., P.V., I.V. and TBV values) and fish had the lowest effect with frying processes because it contains omega-3 fatty acids which have a high durability and a low susceptibility to thermal oxidative processes (Regulska *et al.*, 2002) but potato was highest effect with frying processes because it has low content from PUSFA. Also, to increase the oil stability to heat during frying, prevent oil from oxidation, deteriorative reactions which occurred and improvement fat quality antioxidants must used during frying processes.

Table (9): Changes in acid, peroxide, thiobarbeturic acid and iodine values of fat from fried fish, meat, chicken and potato before frying processes.

Lipid constant	Fish	Meat	Chicken	Potato
A.V. (mg KOH / g lipid)	0.13 ± 0.001	0.26 ± 0.002	0.18 ± 0.01	0.27 ± 0.002
P.V. (meq. peroxides/ kg lipid)	3.89 ± 0.42	5.12 ± 0.47	4.64 ± 0.31	5.97 ± 0.07
T.B.A. (Absorbance at 535 n.m.)	0.420 ± 0.001	0.441 ± 0.001	0.450 ± 0.02	0.482 ± 0.002
I.V. (mg/100g lipids)	106.80 ± 6.51	102.60 ± 7.12	99.00 ± 6.81	98.60 ± 7.21

Table (10): Changes in acid, peroxide, thiobarbeturic acid and iodine values of fat from fried fish, meat, chicken and potato after frying with sunflower oil.

Lipid constant	Fish	Meat	Chicken	Potato
A.V. (mg KOH / g lipid)	0.65 ± 0003	0.96 ± 0.04	0.58 ± 0.005	0.98 ± 0.003
P.V. (meq. peroxides/ kg lipid)	14.46 ± 0.93	16.98 ± 0.90	15.27 ± 1.01	18.48 ± 1.41
T.B.A. (Absorbance at 535 n.m.)	0.730 ± 0.04	0.78 ± 003	0.760 ± 0.02	0.819 ± 0.06
I.V. (mg/100g lipids)	99.20 ± 0.89	94.16 ± 1.43	93.98 ± 0.97	93.80 ± 7.16

5. Use of crude ether extract of turmeric as a natural antioxidant for increasing fat quality indicators of fried potato:

Deep fat frying is a common method of food preparation that important desired sensory characteristics of fried food flavor, golden brown color and crisp texture. During frying at approximately 190°C as oils thermally and oxidatively decompose volatile and non-volatile products are formed which alter functional, sensory and nutritional qualities of oils.

Several ways can be used to overcome oxidatively decompose such use of synthetic or natural antioxidants (Soheili *et al.*, 2002 and Ruiz *et al.*, 1999).

Using synthetic antioxidants such as BHT and BHA are strongly lipophelic fairly heat stable and are used extensively in oil water emulsion but caused several deleterious effect on human health (Farag *et al.*, 2003).

Rosemary, thyme, turmeric and sage contain phenolic substances which act as primary antioxidants and superoxide anion scavengers. These substances ought to be cheap and do not produce any deleterious compounds under the frying conditions.

Curcumin is polyphenol and yellow pigment derived from the plant *Curcuma longa* commonly called turmeric which is spices commonly used in the India diet, food coloring material, used as a medicinal plant in China and extracts from rhizomes are widely used as food additives in Asiatic and central American countries. Also, qualitative constituent of phytochemical of turmeric show that it contained sterols, saponines, flavonoids, glycosides and curcumin (Khanna, 1999; Ukil *et al.*, 2003).

It has been shown to have anti-inflammatory and a powerful antioxidant in both enzymatic and non enzymatic systems, also reduced plated aggregation, hyperlipidaemia and enhances immuno functions (Araujo and Leon, 2001 and Iqbal *et al.*, 2003). From the results in Tables 9, 10 potato had the highest effect with frying processes than other samples thus to prevent potato from oxidation deterioration reactions and improvement fat quality curcumin as a natural antioxidant was mixed with sunflower oil at different concentration during frying.

5.1- Changes in some chemical constants of fried potato supplement with various concentrations of curcumin:

1- Acid value:

The data in Table (11) indicated that acid value of fried potato after heating for 15 min at 175°C in sunflower oil mixed with 500, 1000, 1500ppm curcumin and 200ppm BHT is decrease from 0.98 to 0.88, 0.75, 0.58 and 0.77, respectively. These results indicated that curcumin (polyphenolic compounds) decrease oil hydrolytic rancidity and these results are agreement with (Frankel *et al.,* 1996) they found that herb extracts of rosemary and turmeric inhibited rancidity because it has high content from flavonids.

2- peroxide value:

The results obtained in Table 11 show that increases in the peroxide value of fried potato after frying and decrease after addition different concentrations of curcumin these due to high antioxidant activity of polyphenols that appeared to be due to free radical activity rather than through singlet oxygen generation and delayed rancidity (Beddows *et al.,* 2000), or phenolic substances inhibited hydroperoxides formation by donation of hydrogen atom to lipid radicals (Chuda *et al.,* 1996).

3- Iodine value:

the data in Table 11 show that iodine values of fried potato decreased from 98.6 to 93.80 after frying and increased to 93.53, 94.62, 96.01 and 94.57 after addition 500, 1000, 1500ppm curcumin and 200ppm BHT these due to polyphenolic compounds of curcumin may be prevent double bond of sunflower oil from early stages of oxidation.

Table (11): Changes in acid, peroxide, thiobarbeturic acid and iodine values of fat from fried potato after heating in sunflower oil at 175°C for 15 minutes mixed with 200ppm BHT and different concentrations of ether extract of turmeric.

Treatment	A.V. (mg KOH / g lipid)	P.V. (meq. peroxides/ kg lipid)	I.V. (g/100g lipids)	T.B.A. (Absorbance at 535 n.m.)
500ppm	0.88 ± 0.002	17.22 ± 1.53	93.53 ± 2.64	0.681 ± 0.02
1000ppm	0.75 ± 0.002	13.30 ± 0.102	94.62 ± 7.10	0.670 ± 0.02
1500ppm	0.58 ± 0.001	11.86 ± 0.98	96.01 ± 5.12	0.520 ± 0.009
BHT (200ppm)	0.77 ± 0.001	17.20 ± 0.54	94.57 ± 6.34	0.700 ± 0.001
Control (-) Before frying	0.27 ± 0.00	5.98 ± 0.54	98.6 ± 6.15	0.480 ± 0. 0021
Control (+) After frying	0.98 ± 0.005	18.48 ± 1.06	93.80 ± 8.01	0.819 ± 0.09

4- Thiobarbituric acid value:

The results of TBA test indicated that TBA values of fried potato increased from 0.480 to 0.819 after frying but decrease to 0.681, 0.670, 0.520 and 0.700 after addition 500, 1000, 1500ppm curcumin and 200ppm BHT. These decrease in TBA values may be due to polyphenols (flavonoides) compounds in crude extract exhibited a reduction in the secondary oxidation products.

From the results obtained in Table 11 we concluded that curcumin with various concentration increase the fat quality indicators of fried potato and curcumin with 1000ppm had near effect with BHT but 1500ppm had highest effect than other concentrations as antioxidant. Therefore one would recommend to add 1500ppm from crude ether extract of turmeric to fried foods to depress the development in oxidation reactions at the same time this concentration didn't effect on functional, sensory, nutritive values of fried foods also increasing nutritional value of fried foods. Moreover curcumin with 20mg daily intake for 60 days decrease high levels of peroxidation of both HDL and LDL in human (Ramirez-Basca *et al.,* 1997).

5.2- Changes in fatty acids composition of fried potato as affect with various concentration of curcumin:

For support the results of fat quality of fried potato supplement with various concentrations of curcumin fatty acids from different samples of fried potato were separated, identified by G.L.C. and the results are shown in Table (12). It could be observed that unsaturated fatty acid content were decrease after frying process due to heat frying may be oxidized or breakdown of some double bonds but when addition different concentration of curcumin it was observed that unsaturated fatty acid content increased due to curcumin (effective antioxidant) prevent oxidation and polymerization reactions and antioxidant activity increased with increasing content of curcumin.

6- Use of crude ether extract of turmeric as a natural antioxidant for increasing the stability of heated sunflower oil:

A set of experiments was conducted to evaluate the antioxidant activity of curcumin compounds present in turmeric ether extract. The levels of curcumin compounds added to samples of sunflower oil were 1500ppm as the best concentration for improvement fat quality of fried potato. The control experiment refers to heated sunflower oil with butylated hydroxyl tolune (BHT) at 200ppm.

6.1- Changes in some chemical constants of heated sunflower oil:

1- Acid value:

The data in Table (13) show that acid value of sunflower oil increased significant during heating and was strongly correlated with prolonging the heating period. The addition of various concentrations of curcumin caused a decreasing in the acid value during the heating process was about 1.6 times as great as that of sunflower oil mixed with 1500ppm curcumin, respectively.

These results indicate that curcumin and various curcuminoids (polyphenolic compounds) decreased the oil hydrolytic rancidity. In this respect (Beddows *et al.*, 2000) observed that commercially available herb and spice extracts such as turmeric delayed rancidity and preserved alpha-tocopherol in sunflower oil during heating at (85 - 105°C).

Table (12): Fatty acids composition of fat from fried potato after heating in sunflower oil at 175°C for 15 min mixed with different concentrations of ether extract of turmeric.

Constitute Fatty acid % w/w of total fatty acids	Control	500ppm	1000ppm	1500ppm
Saturated F.A.				
$C_{12:0}$	0.04	0.00	0.01	0.00
$C_{14:0}$	19.44	12.80	10.79	9.09
$C_{16:0}$	21.56	20.12	18.19	16.69
$C_{18:0}$	2.61	2.45	1.50	0.65
Total S.F.A.	43.61	35.39	30.42	26.43
Unsaturated F.A.				
$C_{14:1}$	0.57	0.00	0.02	0.10
$C_{16:1}$	4.80	5.90	6.68	8.40
$C_{18:1}$	16.46	17.55	20.68	23.26
$C_{18:2}$	28.72	30.06	33.70	38.73
$C_{18:3}$	0.64	0.54	0.53	0.60
Total U.S.F.A.	51.19	54.05	61.79	71.09
Other non detected	5.65	10.56	7.79	2.48
UNSAT / SAT ratio	1.17	1.53	2.03	2.70

2- Peroxide value:

The results illustrated in Table (13) showed that the peroxide value gradually increased during 24 a sharp decrease after 48 frying hours because peroxides are formed during the first 24 hours of frying and after that they decompose or polymerize and also showed increase in the peroxide value of heated sunflower oil alone compared with mixed with 200ppm BHT and 1500ppm curcumin. The peroxide value of heated sunflower oil mixed with 1500ppm curcumin at the end of heating process was about 1.2 and 1.08 for BHT with 200ppm and control, respectively.

As expected heating at 180 ± 5°C for 6 hr / day and for 8 consecutive days is sufficient to produce free radical which in turn rapidly react with the atmospheric oxygen to produce hydroperoxides (primary reaction of lipid oxidation).

It appears that phenols which the aromatic ring contains alky groups (hindered phenols) are extremely effective antioxidants such as BHA, BHT, TBHQ and natural antioxidant thymol, rosemary (Frankel *et al.*, 1996).

One would relate the anti-oxidant activity of BHT or other phenolic substances to the inhibition of hydrperoxides formation through donation of hydrogen atom from the group of the phenolic compounds to the lipid radical which in turn produce a stable product. Also plant flavonides have antioxidant activity related to their ability to chelate metals (Nawar, 1996).

3- Thiobarbituric acid (TBA):

The results of TBA test indicate the increase in the TBA values for the heated sunflower oil alone and mixed with 1500ppm of curcumin the data in Table (13) for TBA values at the end of heating process was approximately 126 time as low for 1500ppm curcumin compared with control. Comparing the antioxidant efficiency of BHT at 200ppm with the 1500ppm of curcumin one would observed that the natural phenolic compounds at 1000ppm possessed nearly the same antioxidant activity as that of BHT at 200ppm.

Table (13): Changes in some chemical constants of sunflower oil mixed with BHT and 1500ppm ether extract of tumeric during heating (180 ± 5°C) at various periods.

Frying time (hour)	Sunflower oil (Control)	Sunflower oil BHT (200ppm)	Sunflower oil mixed with curcumin (1500ppm)
Acid value (mg KOH / g oil)			
0	0.38 ± 0.001	0.38 ± 0.002	0.38 ± 0.001
6	1.19 ± 0.09	0.96 ± 0.08	0.86 ± 0.05
12	1.52 ± 0.09	1.26 ± 0.11	0.99 ± 0.07
24	2.26 ± 0.91	1.81 ± 0.09	1.28 ± 0.09
48	2.61 ± 0.07	2.26 ± 0.61	1.58 ± 0.04
Peroxide value (meq. peroxides / kg oil)			
0	4.89 ± 0.09	4.89 ± 0.39	4.89 ± 0.11
6	29.61 ± 1.41	21.35 ± 2.31	19.26 ± 1.01
12	31.62 ± 1.97	29.87 ± 2.67	26.17 ± 1.71
24	42.76 ± 3.62	40.26 ± 3.45	35.78 ± 2.01
48	29.92 ± 2.011	27.62 ± 2.15	23.93 ± 1.07
Thiobarbituric acid test (Absorbance at 535nm)			
0	0.56 ± 0.03	0.56 ± 0.01	0.56 ± 0.05
6	1.51 ± 0.12	1.16 ± 0.02	0.85 ± 0.04
12	3.46 ± 0.29	2.52 ± 0.91	1.89 ± 0.67
24	11.69 ± 0.95	10.77 ±1.02	9.68 ± 0.97
48	7.86 ±0.64	6.89 ± 0.67	6.20 ±.0.63

While 1500ppm level exhibited antioxidant activity superior to that BHT in relating sunflower oil oxidative rancidity (Table 11, 13).

Therefore, one would recommend to add 1500ppm of the phenolic compounds of curcumin to increase oil stability during frying and safe for human health compared with synthetic antioxidants (BHT).

CONCLUSION

1- As result of this study the main chemical constituents present in raw animal samples (fish, meat, chicken) is protein but in vegetable sample (potato) is total hydrolysable carbohydrates.

2- The contents of unsaturated fatty acids higher than saturated before and after frying for all samples and the ratios of TU / TS fatty acids in potato was found about 1.1 as well as this ratio reached about 3.1 in fish and about 2 in meat chicken after frying. The ratios of saturated : monounsaturated : polyunsaturated were slightly different from that recommended ratio.

3- The cholesterol content of fried foods under study ranged from222-373mg/100g sample. Frying conditions have great influences upon cholesterol content since it is sensitive for temperature and time of frying.

4- The correlation between composition of fried foods and hotel category has found to be significant in most of the cases.

5- The kind of oil either or the kind of food had a marked effect on the fat quality indicators and fish was lowest effect with frying than other samples such as potato.
6- To increase fat quality indicators of fried foods such as potato and increasing oil stability curcumin as a natural antioxidant was added with various concentrations ranged from 500 – 1500ppm had compared with BHT at 200ppm. Therefore, it could be concluded that the addition of curcumin with 1500ppm had a highest effect as natural antioxidant because it prevent unsaturated fatty aids of fried foods or oils from oxidation processes at the same time this concentration didn't effect on functional, sensory and nutritive values of fried foods.

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تأثير عمليات القلي علي التركيب الكيمائي للأحماض الدهنية و صفات الجودة و ثبات الزيت لبعض الأطعمة المقلية التي تقدم في بعض الفنادق المصرية

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*** المعهد العالي للسياحة و الفنادق و ترميم الآثار – أبي قير – الإسكندرية

في هذا البحث تم الحصول علي أربعة عينات مختلفه من الأغذية المقلية (سمك – لحم – دجاج – بطاطس) و التي تقدم في بعض الفنادق المنتشرة في محافظة الإسكندرية بغرض معرفة التغيرات التي تحدث في التركيب الكيمائي للأحماض الدهنية و نسبة المواد الدهنية و الكولسترول بعد إجراء عملية القلي في أنواع مختلفة من الزيوت علي حسب طبيعة كل فندق (٥ نجوم ، ٤ نجوم ، ٣ نجوم) و قد وجد أن عمليات القلي المختلفة عموما تزيد من نسبة الأحماض الدهنية غير المشبعة علي حساب نسبة الأحماض الدهنية المشبعة و تزيد نسبة المواد الدهنية الكلية و الكولسترول في الأغذية النانجه و هذا يرجع إلي انخفاض نسبة الرطوبة بها نتيجة لحرارة القلي.

و تم دراسة تأثير عمليات القلي المختلفة علي صفات الجودة للأغذية المقلية و تشمل رقم الحموضة و رقم البيروكسيد و حمض الثيوباربتوتريك (TBA) و الرقم اليودي قبل و بعد القلي و قد وجد أن السمك أقل تأثرا بعمليات القلي من العينات الأخرى و ذلك نظرا لارتفاع محتوي الليبيد به من الأحماض الدهنية عديدة عدم التشبع بينما البطاطس أكثرهم تأثرا نظرا لانخفاض محتواها من المواد الدهنية.

و في محاولة لمنع التأثيرات الضارة لعملية القلي علي بعض الأغذية مثل البطاطس و رفع ثبات الزيت المستخدم للتغيرات غير المرغوبة المصاحبة لعملية القلي فتم استخدام المستخلص الاثيري لنبات الكركم الذي يحتوي علي مادة الكركومين الصفراء اللون كمادة طبيعية مضادة للأكسدة بتركيزات مختلفة تتراوح من ٥٠٠ إلي ١٥٠٠ جزء في المليون كمستخلص اثيري خام مقارنة بمادة BHT كمادة صناعية مضادة للأكسدة بتركيز ٢٠٠ جزء في المليون و أضيفت هذه التركيزات لزيت عباد لشمس أثناء عمليات القلي .

و قد وجد أن الكركومين يرفع من صفات الجودة للمواد الدهنية للبطاطس المقلية و يحميها من الآثار الضارة لعملية القلي و أن أفضل تركيز ١٥٠٠ جزء في المليون مقارنة بـ BHT و هذا التركيز أيضا يزيد من ثبات زيت عباد الشمس للتغيرات الحرارية أثناء عمليات القلي و يحافظ علي محتوي الروابط الزوجية من عمليات الأكسدة و التكسير.

و بذلك يمكن التوصية باستخدام المستخلص الإثيري للكركم بتركيز ١٥٠٠ جزء في المليون في رفع القيمة الغذائية للأطعمة المقلية و زيادة ثبات بعض زيوت القلي علاوة علي القيمة الصحية العالية لمادة الكركومين كمادة طبيعية مضادة للأكسدة في الأنظمة الإنزيمية و غير الإنزيمية.