EVALUATION OF THE NUTRITIONAL QUALITY OF FRIED FISH FILLETS

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Abstract

The aim of this study is to determine how the different frying methods (pan and deep frying) in different oils (sunflower oil, corn oil, soybean oil and cottonseed oil) affect the chemical composition, chemical quality, fatty acids composition and organoleptic evaluation of common carp *Cyprinus carpio L.* and Nile tilapia *Oreochromis niloticus* fillets.

Common carp fish had the highest fillet yield 43.0% compared with the tilapia 38%, while, common carp had the highest frying yield 78.8% compared with the tilapia 77.9% after pan fried in sunflower oil. Also, common carp fillets had the highest frying time 4.5 min compared with the tilapia 2.6 min when pan fried in cottonseed oil. The lipids, proteins ash, peroxide value, free fatty acids, poly unsaturated fatty acids (PUFA) and unsaturated/ saturated (U/S) ratio content were increased after pan and deep fried in different oils for all species, while the moisture, cholesterol and saturated fatty acids (SFA) content were decreased during the pan and deep frying in different oils. No significant difference appeared between the oils used in the frying. On the other side, the average scores of sensory properties showed no significant difference between pan or deep fried in different oils for all species and the deep fried had the highest degree compared to the pan fried.

From the present study, it may be recommended that, the best consumption fried fish fillets (common carp, and tilapia) is the deep frying followed by pan frying in corn oil, sunflower oil, soybean oil and cotton oil, respectively.

INTRODUCTION

Total valuable fish for consumption in Egypt in 2002 reached 953.3 thousand tons, the fish consumption of 14.3 kg of fish per year among people, and a mostly consumed as fried fish.

Most of the polyunsaturated fatty acid (PUFA) *n*-3 studies have been carried out on fish oil concentrates and on fatty fish (Kinsella *et al.,* 1990). Account the qualitative and quantitative fat composition of fatty fish can be greatly affected by seasonality, fishing grounds, as well as industrial and culinary processing (Varela *et al.,* 1990).

Moreover, regular consumption of fish due to its low fat contents, is recommended for the elderly and those with coronary heart disease and hypercholesterolemia (Puwastien *et al.,* 1999).

During frying, interactions among components of food and the culinary fat used take place. These exchanges and interactions would imply that the concentrations of some specific fatty acids in the fish, such as docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), deeply change (Varela *et al.,* 1990). Also, the effect of pan frying and deep frying in olive oil on the fat content in very lean meat (fat= 4.0%), salmon (fat= 26%) and hake (fat= 1.8%) were studied by Martin and Quintana (1994). Both techniques produced fat loss in the meat: pan fried 0.5%, deep fried 1.3% and salmon: pan fried 11.7%, deep fried 7.9%. Hake increased fat content with pan fried 2.4% and with deep fried 5%. Deep frying or pan frying of meat induce fat loss without dietetic relevance. Fat loss in salmon is nutritionally important specially when pan fried. Fat gain in hake is too small to be considered biologically relevant. These results cannot be applied to frying with fats other than olive oil or to frying other foods with the same oil. Echarte *et al.* (2001) and Regulska and Ilow (2002) found that, frying increased the fat content 2-fold, with no difference between samples fried with different oils. Total cholesterol oxidized products (COPs) were 0.74, 2.98, 3.35 and 7.38 microg/g fat in raw, fried with olive oil, fried with soya oil, and roasted salmon, respectively. All cooked samples supplied more omega-6 polyunsaturated fatty acids (PUFAs) than raw samples and showed higher omega-6/omega-3 ratios.

The purposes of this paper are to study how deep and pan-fat-frying of common carp and Nile tilapia fillets (from the Central Laboratory for Aquaculture Research farms, Abbassa, Abou-Hammad, Sharkia governorate) in different culinary fats (sunflower oil, corn oil, soybean oil, and cottonseed oil) are affected, through investigation of: Chemical composition, chemical quality, the fatty acids composition and organoleptic evaluation of the fried fish fillets.

MATERIALS AND METHODS

Samples preparation

Fresh fish, common carp (*Cyprinus carpio L.*) and Nile tilapia (*Oreochromis niloticus*) were used in this study. An initial batch was directly obtained from Central Laboratory for Aquaculture Research (CLAR), Abbassa, Abu-Hammad Sharkia, after

catching in February, 2004. Five kg of each fish species were transported to the laboratory, immediately washed with tap water and slaughtered. The head, scales and all fins of the fish were removed. Thereafter, the fish were washed again and soaked in tap water for one hour and dressed in a fillets style. The total fork length, whole body weight, and fillet weight of each fish was recorded. Each fillet was then assigned to two groups, the first of them was frying by using deep frying method in (sunflower oil, corn oil, soybean oil, and cottonseed oil), and the second group was frying by using pan frying method in (sunflower oil, corn oil, soybean oil, and cottonseed oil) also, according to a randomized incompleted block scheme to ensure that no abnormal or unusual individual would influence values obtained in any treatment category, and that every treatment shared one fillet from one individual fish with every other treatment category. Ten individual fish of each species were used and four fillets were analyzed as either raw fillets or after being cooked by one of the two frying procedures in different oils.

Frying methods

All fillets were cooked to an internal temperature of 71°C (160±5°F) in the thickest portion of the fillet as outlined by Charley and Goertz (1958). The internal temperature of all fillets was measured with a cold-junction of thermocouple apparatus utilizing a Barber-Coleman potentiometer (Model PA-10-1) and copper-constantan leads. A Deep and pan fryer was used for deep and pan frying. The fillets were fried without butter and breading as additional variables. Fillets were immersed in imperial brand (sunflower oil, corn oil, soybean oil, and cottonseed oil) frying oil held at 180°C until an internal temperature of 71°C was reached.

After frying, all fillets were placed on a rack, covered, and allowed to drain by gravity until they had cooled to room temperature. The frying time, initial and final weight of each fillet was recorded and the frying yield was calculated by dividing the weight of the cooked fillet by the initial weight of the raw fillet. Each raw or fried fillet was then thoroughly ground and mixed to provide a homogeneous mixture and stored at –20 °C in freezer for chemical analysis.

Analytical techniques

Homogeneous mixtures of each fillet (3-5g) were dried at 105°C to constant weight by standard methods (AOAC, 1990) for moisture determination. Total solids were calculated by subtracting the moisture content of each sample from 100. Total protein was determined by kjeldahl procedure using a 6.25 conversion factor

according to the method described in AOAC (1990). Total lipid was measured by extraction from a 2-g portion of dried samples for each treatment by AOAC (1990). Ash was determined by heating at 550°C using a muffle furnace according to method outlined in AOAC (1990). The constituent Fatty acids present in the lipid extracted from each fillet was measured by gas-liquid chromatography after being liberated and esterified by a modification of AOAC (1990). Cholesterol was determined according to method described by Wu and Lillard (1998).

Organoleptic evaluation

Samples were organoleptic evaluated for taste, flavour, tenderness and overall acceptability. Scoring the organoleptic properties of the samples was carried out by giving grades ranging from zero to 10 according to Teeny and Miyauchi (1972) as estimated by the following scheme:

Score	Description	Score	Description
10	Ideal	4	Fair
9	Excellent	3	Poorly fair
8	Very good	2	Poor
7	Good	1	Very poor
6	Fairly good	0	Repulsive
5	Acceptable		

Statistical analysis

Three replications of each trial were performed. Frying yield, chemical composition, chemical quality and sensory data were analyzed using Analysis of Variance ANOVA and means were separated by Duncan' test at a probability level of $P<0.05$ (SAS, 2000).

RESULTS AND DISCUSSION

Fillet yield

The mean and range of weight, length and fillet yield of common carp (*Cyprinus carpio L.*) and Nile tilapia (*Oreochromis niloticus*) used in this study, are presented in Table 1. The results indicated that, the fillet yield for each species was expressed as the total weight of both boneless, skinless fillets divided by the total weight of the whole fish in the round. The fillet yield was found to vary from one species to another (Table 1), and was related to the specific anatomical makeup of the species. The size of each individual did not greatly influence fillet yield. The common carp varied greatly

in size, but, individual fillet yield was consistently between 39-46%. There was more variation in the yield from tilapia in which an average of 38% of the whole body weight could be used as edible fillet flesh. Although this fillet yield data are taken from ten individual fish caught in a specific location, it can be used as a rough estimate for the species. The actual yield from any individual fish is influenced by a variety of physiological and environmental factors that determine the amount of muscle tissue present in each individual. The achieved data are in agreement with those reported by Gall *et al.* (1983).

Frying yield and frying time

The mean frying yield and frying time for each species is given in Table 2. No significant differences ($p>0.05$) in frying yields were found between pan and deep fried fish fillets for common carp or tilapia fillets. Deep fried fillets in all oils species used in the study had the shortest required frying time compared with the pan fried fish fillets. Overall frying yield was, however, proportional to frying time. Deep fried fillets required short times, and the frying yield was the lowest. Frying yield appears to be influenced by frying rate, composition and frying method. The degree of influence is related to the size and surface area per unit volume exposed to the frying medium. These data suggest that frying yield is related to size (based on total fillet weight) and composition. These results are in a close agreement with those reported by Mai *et al.* (1978) and Bell *et al.* (2001).

Chemical composition

The moisture content in all fried common carp and tilapia fillets was lower than that in raw fillets from each species (Table 3) Moisture was lost from these fillets during frying. The amount of moisture lost during each frying process was consistent. The least moisture was lost from all pan fried fillets. The moisture content of pan or deep fried fish fillets in different oils was approximately the same for each species of fish.

The lipid contents of raw fillets were 4.72, 1.85% in raw common carp and tilapia fillets, respectively (Table 3). The changes observed in the amount of total lipid present in fried fillets appear to be directly related to the original lipid content of the raw fillet. The lipid content of pan or deep fried in different oils, all species fillets significantly increased ($P>0.05$) when compared to raw fillets. These data indicated that the gain of lipid material from fish fillets to the frying medium is related to the lipid content of the raw fillet. The common carp fillets (raw lipid content 4.72%) had

1.6 and 1.9 times more lipid than pan and deep fried, respectively. Tilapia fillets (raw lipid level 1.85%) had 2.6 and 3.6 times more lipid after pan and deep fried, respectively. This suggests that the amount of absorption of lipid from an oil frying medium decreases as the lipid concentration in the raw fillet increases until a saturation level is reached where there is no net absorption or elusion of lipid. A similar study (Mai *et al.* 1978) also, showed that fish fillets containing lower amounts of lipid tended to absorb more oil during frying and that this absorption was further enhanced if breading was present.

There was an apparent net increase in protein levels in cooked fillets from all species when compared to the raw fillets on a wet weight basis (Table 3). No significant difference ($P>0.05$) between pan or deep fried fish fillets in different oils was observed while there were significant differences between pan and deep fried fish fillets. The effect of frying on protein levels in fillets from these species was not clearly discernable. The error inherent in measuring Kjeldahl nitrogen and using a factor 6.25 to calculate protein levels in fish fillets has likely influenced the differences in protein levels that were observed.

The ash level in fried fillets from all species was higher than that found in raw fillets from each species on a wet weight basis (Table 3). Moisture losses that occurred during frying resulted in an apparent concentration of ash constituents in fillets. Common carp fillets fried in different oils had higher concentrations when compared to their respective raw fillets concentrations.

These results coincide with those given by Mai *et al.* (1978), Varela *et al.* (1990), Muniz *et al.* (1992), Martin and Quintana (1994) and Echarte *et al.* (2001).

Chemical quality

Peroxide value (PV), cholesterol and free fatty acids (FFA) index are the most used indicators for chemical quality for fish fillets. Results presented in Table 4 indicated that the formation of PV as milliequivalents peroxide/ kg lipid, cholesterol (mg/g oil) and FFA (%) were affected by frying of fish fillets in different oils. Results indicated no significant increase ($P<0.05$) in PV-value and FFA during pan and deep frying process in different oils. This indicates the occurrence of some oxidation in lipids by the thermal treatment, while, significant increases ($P<0.05$) were observed in cholesterol during pan and deep frying process in different oils. These results are in harmony with those obtained by Muniz *et al.* (1992), Echarte *et al.* (2001) and Regulska and Ilow (2002).

Fatty acids

Data in Tables 5 and 6 showed the fatty acids composition of raw and fried fillets from each fish species along with the fatty acid composition of the frying oils used for pan and deep frying. Fresh frying oils were used when fillets from each species were pan and deep fried and the oils were not analyzed after frying.

Pan and deep fried methods had an increase in the fatty acids (Monounsaturated fatty acids MUFA, Polyunsaturated fatty acids PUFA and Unsaturated/ Saturated U/S ratio). Data showed the decrease in SFA for all species during frying by pan and deep fried fillets compared to the raw fillets for all species. On the other side, the predominant fatty acids were C16:0, C18:1 and C18:2 in the fillets (raw and fried by different methods) for all species. The difference between the pan and deep fried methods due to different amounts of the fatty acids was absorbed during frying. These results agree with those achieved by Mai *et al.* (1978), Muniz *et al.* (1992) and Echarte *et al.* (2001).

Organoleptic evaluation

The average scores of sensory properties of pan and deep fried two species of fish in different oils are shown in Table 7. It is proved that, the fillets deep and pan fried, respectively, in corn oil for all species had the highest scores of taste, flavour, tenderness overall acceptability, followed by deep and pan fried fillets, respectively, in sun flower oil, soybean oil and cottonseed oil, respectively. All fillets fried by different methods were actually evaluated as "Good", while, pan and deep fried in corn oil were as best as "Very Good" to common carp and tilapia fillets. These results are in good agreement with those reported by Guen *et al.* (2001).

From the results obtained in the present study, it may be recommended that, there are no significant difference between different oils used in frying fish fillets. The best method for consumption of fried fish fillets (common carp, and tilapia) is deep frying followed by pan frying in corn oil, sunflower oil, soybean oil and cotton oil, respectively.

Table 1. Mean and range of weight, length and fillet yield of fish used in the frying.

	Whole body wt. (g)	Fork length (cm)	Fillet yield (%)
Common carp	630 – 2220 (1400)	30 - 40 (35)	38.7 – 45.5 (43.0)
Nile tilapia	190 – 270 (250)	10 – 15 (12)	38.0 – 45.2 (38.0)

Table 2. Mean ± standerd error frying yield (Y=percent) and frying time (T=minutes) for pan (A) and deep (B) fried fish fillets in different oils.

Oil sp.		sunflower oil		corn oil		soybean oil		cottonseed oil	
Frying methods		A	B	A	B	A	B	A	B
Common carp	Y	78.8 ± 0.61 a	77.1 ± 0.52 ab	78.6 ± 0.43 a	76.8 ± 0.57 ab	78.7 ± 0.61 a	76.9 ± 0.47 ab	78.5 ± 0.70 a	76.7 ± 0.51 ab
	T	4.3	3.9	4.4	4.0	4.3	3.9	4.5	4.1
Nile tilapia	Y	77.9 ± 0.55 a	76.5 ± 0.72 ab	77.8 ± 0.47 a	76.3 ± 0.37 ab	77.8 ± 0.63 a	76.4 ± 0.58 ab	77.6 ± 0.71 a	76.2 ± 0.39 ab
	T	2.5	2.1	2.5	2.2	2.4	2.2	2.6	2.3

[a-b] Means within a column with the same superscript significantly different ($P<0.05$).

Table 3. Chemical composition on a wet weight basis for raw, pan (A) and deep (B) fried fish fillets in different oils.

Oil sp.	Raw fillets	sunflower oil		corn oil		soybean oil		cottonseed oil	
Frying methods		A	B	A	B	A	B	A	B
Moisture %									
Common carp	76.41± 0.57 a	70.15 ± 0.42 b	65.52 ± 0.51 c	69.97 ± 0.37 b	65.27 ± 0.44 c	70.06 ± 0.62 b	65.35 ± 0.53 c	69.88 ± 0.72 b	65.81 ± 0.63 c
Nile tilapia	78.50± 0.74 a	71.61 ± 0.62 b	66.70 ± 0.54 c	71.52 ± 0.60 b	66.52 ± 0.47 c	71.52 ± 0.49 b	66.61 ± 0.55 c	71.33 ± 0.57 b	66.44 ± 0.38 c
Total solids %									
Common carp	23.59± 0.19 c	29.85 ± 0.16 b	34.48 ± 0.18 a	30.33 ± 0.14 b	34.73 ± 0.19 a	29.94 ± 0.13 b	34.65 ± 0.16 a	30.12 ± 0.14 b	34.19 ± 0.17 a
Nile tilapia	21.50± 0.12 c	28.39 ± 0.15 b	33.30 ± 0.18 a	28.48 ± 0.16 b	33.48 ± 0.18 a	28.48 ± 0.15 b	33.39 ± 0.17 a	28.68 ± 0.14 b	33.56 ± 0.19 a
Lipid %									
Common carp	4.72± 0.03 c	7.40± 0.05 b	8.86± 0.06 a	7.42± 0.05 b	8.89± 0.06 a	7.42± 0.04 b	8.88± 0.05 a	7.43± 0.07 b	8.82± 0.03 a
Nile tilapia	1.85± 0.01 c	4.81± 0.03 b	6.60± 0.04 a	4.82± 0.03 b	6.62± 0.04 a	4.82± 0.02 b	6.61± 0.03 a	4.83± 0.04 b	6.62± 0.02 a
Protein %									
Common carp	16.00± 0.11 c	19.29 ± 0.12 b	22.21 ± 0.14 a	19.33 ± 0.12 b	22.29 ± 0.15 a	19.32 ± 0.11 b	22.27 ± 0.16 a	19.37 ± 0.13 b	22.10 ± 0.12 a
Nile tilapia	18.03± 0.12 c	21.39 ± 0.14 b	24.38 ± 0.17 a	21.42 ± 0.15 b	24.45 ± 0.16 a	21.42 ± 0.13 b	24.42 ± 0.18 a	21.47 ± 0.14 b	24.48 ± 0.17 a
Ash %									
Common carp	2.23± 0.07 ab	2.33± 0.08 a	2.53± 0.06 a	2.34± 0.07 a	2.54± 0.05 a	2.34± 0.06 a	2.54± 0.08 a	2.33± 0.03 a	2.52± 0.04
Nile tilapia	1.30± 0.05 ab	1.57± 0.06 a	1.70± 0.04 a	1.58± 0.07 a	1.71± 0.05 a	1.58± 0.05 a	1.71± 0.07 a	1.57± 0.02 a	1.71± 0.03 a

[a-c] Means within a column with the same superscript significantly different ($P<0.05$).

Table 4. Chemical quality on a wet weight basis for raw, pan (A) and deep (B) fried fish fillets in different oils.

Oil sp.	Raw	sunflower oil		corn oil		soybean oil		cottonseed oil	
Frying methods	fillets	A	B	A	B	A	B	A	B
Peroxide value (milliequivalents peroxide/kg lipid)									
Common carp	3.21±	4.15±	4.52±	3.97±	4.32±	3.96±	4.31±	3.42±	3.72±
Nile tilapia	0.05 b	0.07a	0.06 a	0.03 a	0.07 a	0.05 a	0.08 a	0.03 ab	0.06 ab
	3.02±	3.68±	4.38±	3.81±	4.19±	3.80±	4.18±	3.28±	3.61±
	0.06 b	0.04 ab	0.05 a	0.04 ab	0.07 a	0.03 ab	0.04 a	0.06 ab	0.07 ab
Cholesterol (mg/g Oil)									
Common carp	23.84±	7.91±	8.34±	10.91±	11.50±	11.06±	11.66±	20.0±	21.13±
Nile tilapia	0.15 a	0.11 c	0.10 c	0.13 b	0.11 b	0.10 b	0.13 b	0.14 a	0.15 a
	14.34±	4.76±	5.22±	6.56±	7.20±	6.65±	7.30±	12.06±	13.23±
	0.12 a	0.08 c	0.09bc	0.10 b	0.09 b	0.11 b	0.09 b	0.13 a	0.12 a
Free Fatty Acids (%)									
Common carp	0.081±	0.104±	0.114±	0.100±	0.109±	0.099±	0.108±	0.086±	0.093±
Nile tilapia	0.006ab	0.008a	0.008a	0.007a	0.008a	0.006a	0.008a	0.005ab	0.006a
	0.032±	0.042±	0.046±	0.040±	0.044±	0.041±	0.044±	0.035±	0.038±
	0.002 ab	0.003 a	0.004a	0.003a	0.004a	0.002a	0.003a	0.001ab	0.002ab

[a-c] Means within a column with the same superscript significantly different ($P<0.05$).

Table 5. Fatty acids composition (% w/w of total fatty acids) of raw, pan (A) and deep (B) fried Common carp fillets in different oils.

Oil sp.	Raw fish fillets	sunflower oil			corn oil			soybean oil			cottonseed oil		
Frying methods		Raw oil	A	B	Raw oil	A	B	Raw oil	A	B	Raw oil	A	B
C14:0	1.100	-------	0.970	1.000	-------	0.860	0.660	0.100	0.830	0.520	0.700	0.790	0.530
C16:0	27.03	7.000	19.72	15.50	11.70	15.42	13.28	10.70	17.56	15.73	22.60	20.20	18.19
C18:0	2.700	3.300	3.510	3.600	2.300	2.600	2.650	3.400	3.300	2.950	2.800	2.930	2.490
C20:0	1.650	-------	1.220	0.200	0.200	1.550	1.530	0.200	1.510	1.370	-------	-------	-------
C22:0	0.690	-------	0.550	0.510	-------	------	------	------	------	------	------	------	------
C23:0	0.610	-------	0.510	0.550	-------	------	------	------	------	------	------	------	------
C24:0	0.370	-------	0.310	0.280	-------	------	------	------	------	------	------	------	------
ΣSFA	34.15	10.30	26.43	21.64	14.20	20.43	18.12	14.40	23.20	20.57	26.10	23.92	23.92
C16:1	4.550	-------	10.11	11.37	-------	3.620	2.730	------	3.820	2.370	0.400	2.820	2.820
C18:1	33.32	14.30	30.03	26.52	26.60	------	27.94	22.80	61.65	56.95	19.80	27.69	27.69
C20:1	0.730	-------	0.530	0.130	-------	0.550	0.410	------	0.610	0.380	-------	0.280	0.280
C22:1	0.210	-------	1.210	1.820	-------	0.200	0.160	------	0.170	0.110	-------	0.570	0.570
ΣMUFA	39.71	14.30	41.88	39.84	26.60	35.00	31.24	22.80	66.25	59.81	20.20	31.36	31.36
C18:2	24.33	75.40	29.83	35.51	58.40	43.36	49.34	54.50	9.450	16.91	53.70	44.55	44.55
C18:3	1.710	-------	1.860	3.010	0.800	1.210	1.300	8.300	1.100	2.710	-------	0.170	0.170
ΣPUFA	26.14	75.40	31.69	38.52	59.20	44.57	50.64	62.80	10.55	19.62	53.7	44.72	44.72
U/S Ratio	1.930	8.700	2.780	3.620	6.040	3.89	4.520	5.940	3.310	3.860	2.830	3.180	3.180

Table 6. Fatty acids composition (% w/w of total fatty acids) of raw, pan (A) and deep (B) fried Nile tilapia fillets in different oils.

Oil sp.	Raw fish fillets	sunflower oil			corn oil			soybean oil			cottonseed oil		
Frying methods		Raw oil	A	B	Raw oil	A	B	Raw oil	A	B	Raw oil	A	B
C14:0	3.100	------	3.000	2.600	------	0.800	0.700	0.100	0.570	0.400	0.700	1.120	0.700
C16:0	22.70	7.000	15.42	13.75	11.70	12.92	11.40	10.70	17.81	15.80	22.60	17.01	15.40
C18:0	5.000	3.300	5.620	4.100	2.300	4.550	3.900	3.400	3.080	2.700	2.800	4.310	3.800
C20:0	------	------	------	------	0.200	0.900	1.000	0.200	0.310	0.400	------	------	------
C22:0	0.400	------	0.300	0.210	------	------	------	------	------	------	------	------	------
C23:0	0.330	------	------	------	------	------	------	------	------	------	------	------	------
C24:0	0.510	------	0.450	0.330	------	------	------	------	------	------	------	------	------
		------											
ΣSFA	32.04	10.30	24.80	21.99	14.20	19.17	17.00	14.40	21.77	19.30	26.10	22.44	19.90
C16:1	2.100	------	8.68	7.530	------	4.620	4.300	------	2.960	2.500	0.400	1.930	1.500
C18:1	35.75	14.30	31.35	27.90	26.60	29.98	26.20	22.80	63.70	57.70	19.80	29.12	26.10
C20:1	0.200	------	1.82	1.800	------	0.170	0.200	------	0.150	0.100	------	0.160	0.100
C22:1	0.530	------	0.650	0.700	------	0.750	1.000	------	0.420	0.400	------	0.620	0.700
ΣMUFA	40.30	14.30	42.50	37.93	26.60	35.52	31.70	22.80	67.23	60.70	20.20	31.83	28.40
C18:2	23.56	75.40	32.70	40.08	58.40	42.92	50.30	54.50	10.12	18.40	53.70	44.99	51.00
C18:3	4.100	------	------	------	0.800	2.390	1.000	8.300	1.110	1.600	------	0.74	0.700
ΣPUFA	27.66	75.40	32.70	40.08	29.2	45.31	51.30	62.80	11.23	20.00	53.70	45.73	51.70
U/S Ratio	2.120	8.700	2.64	3.550	6.04	4.220	4.880	5.940	3.600	4.180	2.83	3.46	4.030

Table 7. Organoleptic evaluation of pan (A) and deep (B) fried fish fillets in different oils.

Oil sp.	sunflower oil		corn oil		soybean oil		cottonseed oil	
Frying methods	A	B	A	B	A	B	A	B
Taste								
Common carp	7.5±0.0 ab (G)	8.0±0.07 a (VG)	8.0±0.07 a (VG)	8.5±0.07 a (VG)	7.2±0.05 b (G)	7.7±0.06 ab (G)	7.0±0.05 b (G)	7.5±0.06 ab (G)
Nile tilapia	8.0±0.07 ab (VG)	8.5±0.06 a (VG)	8.3±0.06 ab (VG)	8.7±0.07 a (VG)	7.7±0.05 b (G)	8.2±0.07 ab (VG)	7.4±0.05 b (G)	8.0±0.06 ab (VG)
Flavor								
Common carp	7.8±0.06 ab (G)	8.2±0.05 a (VG)	8.0±0.05 a (VG)	8.6±0.07 a (VG)	7.5±0.04 ab (G)	8.0±0.06 a (VG)	7.5±0.05 ab (G)	8.0±0.04 a (VG)
Nile tilapia	8.8±0.07 ab (VG)	9.0±0.05 a (E)	9.0±0.06 a (E)	9.3±0.05 a (E)	8.0±0.07 b (VG)	8.5±0.04 ab (VG)	8.0±0.05 b (VG)	8.5±0.06 ab (VG)
Tenderness								
Common carp	7.0±0.04 a b (G)	7.5±0.07 a (G)	7.4±0.06 a (G)	7.7±0.03 a (G)	7.3±0.07 ab (G)	7.2±0.05 ab (G)	7.4±0.06 a (G)	7.2±0.04 ab (G)
Nile tilapia	7.3±0.05 ab (G)	7.7±0.03 a (G)	7.5±0.05 a (G)	7.9±0.07 a (G)	7.0±0.06 ab (G)	7.5±0.04 a (G)	7.0±0.07 ab (G)	7.4±0.03 ab (G)
Overall acceptability %								
Common carp	74.3±0.54 ab (G)	79.0±0.63 a b (G)	78.0±0.52 a (G)	82.7±0.61 a (VG)	73.3±0.39 b (G)	76.3±0.61 a (G)	73.0±0.54 b (G)	75.7±0.46 ab (G)
Nile tilapia	79.7±0.43 ab (G)	84.4±0.47 a (VG)	82.7±0.55 a (VG)	86.3±0.48 a (VG)	75.7±0.61 b (G)	80.7±0.38 a (VG)	74.7±0.45 b (G)	79.7±0.52 ab (G)

[a-b]Means within a column with the same superscript significantly different (P<0.05).

E= Excellent. V.G.= Very good. G= Good. F.G.= Fairly good.

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تقييم الجودة الغذائية لشرائح الأسماك المقلية

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المعمل المركزي لبحوث الثروة السمكية بالعباسة- مركز البحوث الزراعية- وزارة الزراعة- الدقى- الجيزة.

فـــى هـــذا البحـــث تـــم دراسة تأثير القلى السطحى والعميق فى الزيوت المختلفة (زيت عباد الشمس، زيت الذرة، زيت فول الصويا وزيت بذرة القطن) على التركيب الكيميائى ومركبات الجودة الكيميائية والأحماض الدهنية وكذلك على الخواص الحسية لشرائح أسماك المبروك والبلطى.

أوضـــحت النتائج أن سمك المبروك أعطى أكثر نسبة تصافى ٤٣,٠% مقارنة بسمك البلطى ٣٨% ، بينما كانت أعلا محصلة قلى لشرائح المبروك ٧٨,٨% مقارنة بمحصلة قلى شرائح البلطى ٧٧,٩% المقلـــية بطـــريقة القلـــى السطحى فى زيت عباد الشمس. كذلك فان شرائح سمك المبروك أعطت أطول فترة قلى ٤,٥ دقيقة بطريقة القلى السطحى فى زيت بذرة القطن مقارنة بشرائح البلطى التى احتاجت إلى ٢,٦ دقيقة. كما أوضحت النتائج حدوث زيادة تدريجية فى محتوى شرائح الأسماك المخـــتلفة من الدهن، البروتين، الرماد، رقم البيروكسيد، الأحماض الدهنية الحرة، الأحماض الدهنية عديـــدة عـــدم التشبع والنسبة بين الأحماض الدهنية المشبعة والغير مشبعة فى كل طرق القلى سواء الســـطحى او العمـــيق فـــى الـــزيوت المختلفة. كما أوضحت النتائج حدوث انخفاض فى قيم كل من الـــرطوبة، الكولســـتيرول والأحماض الدهنية المشبعة خلال طرق القلى المختلفة. لا توجد اختلافات معنوية بين قيم الشرائح المقلية فى الزيوت المختلفة المستخدمة سواء بالقلى السطحى أو العميق. من ناحـــية أخـــرى أظهرت قيم الخواص الحسية (الطعم، الرائحة، الطراوة والقابلية العامة) عدم وجود اخـــتلافات معـــنوية بيـــن شرائح الأنواع المختلفة المقلية فى زيوت مختلفة سواء بالقلى السطحى أو العميق، وكانت أعلا القيم لشرائح القلى العميق مقارنة بقيم شرائح القلى السطحى.

مـــن نـــتائج هـــذه الدراسة، يتضح أن افضل طرق استهلاك شرائح اسماك المبروك العادى والـــبلطى المقلية كانت طريقة القلى العميق خاصة فى زيت الذرة يليها زيت عباد الشمس وزيت فول الصويا ثم زيت بذرة القطن، على الترتيب.