EVALUATION OF THE NUTRITIONAL QUALITY OF COOKED FISH FILLETS BY DIFFERENT METHODS

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(Manuscript received 10 December 2003)

Abstract

The goal of this study is to determine how different cooking methods (steaming, baking, broiling, deep frying and cooking in microwave) affect the proximate, minerals and fatty acids composition and organoleptic evaluation of common carp *Cyprinus carpio L.*, catfish *Clarias gariepinus* and Nile tilapia *Oreochromis niloticus* fillets. Common carp fish had the highest fillet yield 43.6% and cooking time 21.2 min when cooked by steaming method, while, the tilapia had the highest cooking yield after being cooked by steaming method 85.7%. Lipids, proteins and ash content were gradually increased during cooking by different methods for all species, and the highest levels were the fillets cooked by deep fried method, while, the moisture content was gradually decreased during the different cooking methods. All the minerals increased during different cooking methods, except the steaming method which showed a decrease in all minerals compared with the raw fillets. The fatty acids composition mono unsaturated fatty acids (MUFA), poly unsaturated fatty acids (PUFA) and unsaturated/ saturated (U/S) ratio of all species fillets cooked in all methods were decreased compared to the raw fillets, except the cooking in deep fried method which showed an increase in the fatty acids composition. The results showed an increase in saturated fatty acids (SFA) for all species fillets cooked by different methods except cooking by deep fried method. It had a decrease in SFA compared to the raw fillets of all species. On the other side, the average scores of sensory properties were not significantly different between baked and broiled methods for all species and it had the highest degree compared to the other methods. From the results obtained in the present study, it may be recommended that, the best consumption fish fillets (common carp, catfish and tilapia) is cooking by baking or broiling method, deep frying, microwave and steaming methods, respectively.

INTRODUCTION

Both eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), are of the most important n-3 PUFA. They were least, reduced by steaming by and pan frying, microwave cooking, deep fat frying most in order (Kim *et al.,* 1999).

Mun *et al.* (1999) demonstrated that both cooking methods (boiled and steamed) reduced total lipids and ash contents in Loach, although total amino acids (including essential amino acids) were little altered.

Puwastien *et al.* (1999) found that boiled and steamed and raw fish had similar protein contents, while those of roasted, fried and semi-processed fish were higher.

Echarte *et al.* (2001) declared that roasting did not modify the fat content from that of raw fish samples. Frying increased the fat content 2-fold, with no difference between samples fried with different oils.

Regulska and llow (2002) revealed that culinary process like boiling, grilling and frying whether done conventionally or with a microwave oven did not lead to a reduction in the n-3 polyunsaturated fatty acids (PUFA) fraction of the total fatty acids, indicating that these fatty acids have a high durability and low susceptibility to thermal oxidative processes.

This study presents the influence of various cooking methods on the nutritional composition of selected fish fillets from the Central Laboratory for Aquaculture Research farms.

MATERIALS AND METHODS

Samples preparation

Fresh fish, common carp *Cyprinus carpio L.,* catfish *Clarias gariepinus* 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, in January 2002. Five kg of each species were transported to the laboratory, immediately washed with tap water. The head, scales and all fins were removed using a sharp knife. 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 one of six treatments categories (raw, steamed, baked, broiled, deep fried or microwave) 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 five cooking procedures.

Cooking 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. Fillets steamed in cooker (12L., Model express and made in Morocco) at boiling water temperature. Fillets were wrapped in aluminum foil, placed in a household oven (stone) and baked at 180°C (356°F). Broiled fish fillets were cooked in a household oven on an aluminum rack 5 centimeters from the upper heating element set at 180°C. A Deep Fryer was used for deep frying, the fillets were fried without butter and breading as additional variables. Fillets were immersed in Imperial brand sunflower cooking oil held at 180°C until an internal temperature of 71°C was reached. Microwave oven cooked fillets were placed in a glass baking dish and cooked in a Litton Menu-master system 70/50 microwave oven operating at 2450 MHZ. Fillets were cooked in the microwave oven in 15-sec intervals, immediately removed and the internal temperature measured with the thermocouple.

After cooking, all fillets were placed on a rack, covered, and allowed to drain by gravity until they had cooled to room temperature. The cooking time and initial and final weight of each fillet was recorded and the cooking yield was calculated by dividing the weight of the cooked fillet by the initial weight of the raw fillet. Each raw or cooked 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, total solids, total protein, total lipid and ash determination .

The mineral content of each ash sample was assayed after dissolving in 5N HCl. This solution was quantitatively transferred to a volumetric flask and brought to a final concentration of 0.2N HCl with deionized water. All minerals were analyzed with atomic absorption spectrophotometers (Perkin-Elmer Corp., Model PE 503 and 5000) equipped with hollow cathode lamps specific for each element and an air-acetylene flame. The constituent Fatty acids present in the lipid extracted from each fillet was measured by gas-liquid chromatography after liberated and esterified by a modification of AOAC (1990).

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).

Statistical analysis

Three replications of each trial were performed. Cooking yield and sensory data were analyzed using 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.,* catfish *Clarias gariepinus* and Nile tilapia *Oreochromis niloticus* 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 40-46%. 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 these fillet yield data were 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).

Cooking yield and cooking time

The mean cooking yield and cooking time for each species is given in Table 2. No significant differences (p>0.05) in cooking yields were found between baked or broiled fillets. The mean yield for deep fried common carp, catfish and tilapia fillets was significantly lower (p<0.05) than the yield with other cook methods, and the mean yields of steaming cooked fillets was higher. No significant differences were found between the cook yield of steaming and microwave cooked fillets for any species. Microwave cooked fillets had the shortest required cook time. Overall cooking yield was not, however, proportional to cooking time. Deep fried fillets required short times, but, the cook yield was the lowest. Cooking yield appears to be influenced by cooking rate, composition and cooking method. The degree of influence is related to the size and surface area per unit volume exposed to the cooking medium. These data suggest that cooking 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).

Proximate composition

The moisture content in all cooked common carp, catfish and tilapia fillets was lower than that in raw fillets from each species (Table 3). Moisture was lost from these fillets during cooking. The amount of moisture lost during each cooking process was consistent. The least moisture was lost from all steaming cooked fillets. The moisture content of baked and broiled cooked fillets was approximately the same, and deep fried fillets consistently lost the most moisture (and total weight) during cooking.

The lipid content of raw fillets were 4.72, 2.51 and 1.85% in raw common carp, catfish and tilapia fillets, respectively (Table 3). The changes observed in the amount of total lipid present in cooked fillets appear to be directly related to the original lipid content of the raw fillet. The lipid content of steamed, baked, broiled and microwave cooked all species fillets increased slightly when compared to raw fillets. The amount of moisture and lipid lost during cooking, appears to be influenced by the original lipid content of fillet when it was cooked in a medium that did not contain additional lipid material (not fried). The lipid content of deep fried all samples fillets was higher than lipid levels in both the raw fillets and fillets cooked by the other methods. Significant amounts of lipid was absorbed from the sunflower cooking oil medium by the fillets from these three species. This data indicated that, the gain of lipid material from fish fillets to the cooking medium was related to the lipid content of the raw fillet. The common carp fillets (raw lipid content 4.72%) had 1.9 times more lipid when deep fried. Catfish fillets (2.51% lipid in raw fillets) had 2.7 times more lipid after deep frying, and finally tilapia fillets (raw lipid level 1.85%) had 3.35 times more lipid after deep frying. This suggests that the amount of absorption of lipid from an oil cooking medium decreased as the lipid concentration in the raw fillet increased until a saturation level is reached where there is no net absorption or elusion of lipid. A similar study also showed that fish fillets containing lower amounts of lipid tended to absorb more oil during cooking and that this absorption was further enhanced if breading was present (Mai *et al.* 1978).

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). Steamed common carp had a lower protein content 18.73% compared to the other cooking methods for all species. Deep fried tilapia fillets had a highest mean protein content 24.38%. The effects of cooking on protein levels in fillets from these species ware not clearly discernable. The error inherent in measuring Kjeldahl nitrogen and using a factor 6.25 to calculate protein levels in fish fillets had likely influenced the differences in protein levels that were observed.

The ash level in cooked 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 cooking resulted in an apparent concentration of ash constituents in fillets. Common carp fillets cooked by different methods had higher concentrations when compared to their respective raw fillets concentrations.

These results coincided with those given by Mai *et al.* (1978), Gall *et al.* (1983), Kim *et al.* (1999) and Puwastien *et al.* (1999).

Minerals

Sodium concentration in raw and cooked fillets from each species paralleled the ash levels in these fillets (Table 4). Cooked fillets from all species had higher sodium levels than the raw fillets when compared on a wet weight basis. Sodium concentrations were the lowest in all steamed species fillets compared to sodium levels in all cooking methods and raw fillets. However, in similar comparisons, fillets from the fatty species, common carp had higher sodium concentrations when compared to raw fillets.

The mean phosphorus concentrations found in all of the cooked fillets from all three species were higher than the mean concentration in raw fillets, except steamed fillets which were lower than the concentration of raw fillets (on a wet weight basis). Phosphorus was not lost from these fillets when baked, broiled, deep fried or cooked in microwave.

Slow increase was observed when mean concentration of calcium, zinc, iron and copper in raw and cooked common carp, catfish and tilapia fillets were compared, while, the steamed fillets had the lowest levels of these minerals compared to the raw fillets and other all cooking methods. Calcium levels fluctuated greatly and may be attributed to fragments of bone or scale in the fillets. Deep fried fillets for all species had the highest level of calcium, zinc, iron and copper compared to the raw and other cooking methods. These results are in line with those obtained by Gall *et al.* (1983), Kim *et al.* (1999) and Tahvonen *et al.* (2000).

Fatty acids

Data in Table 5 showed the fatty acids composition of raw and cooked fillets from each fish species along with the fatty acid composition of the sunflower cooking oil used for deep frying. Fresh sunflower cooking oil was used when fillets from each species were deep fried and the oil was not analyzed after cooking.

Slow decrease in the fatty acids composition Monounsaturated fatty acids (MUFA), Polyunsaturated fatty acids (PUFA) and Unsaturated/ Saturated (U/S) ratio of all species fillets cooked in different methods compared to the raw fillets, except the deep fried method had an increase in the fatty acids (MUFA, PUFA and U/S ratio). Data showed the increase in SFA for all species during cooking by steamed, baked, broiled and microwave methods compared with the raw fillets, while deep fried fillets had a decrease in SFA 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 cooked by different methods) for all species. The difference between the deep fried method compared to the other cooking methods due to large amounts of the fatty acids was absorbed during deep frying. These results agreed with those achieved by Mai *et al.* (1978) Gall *et al.* (1983) Kim *et al.* (1999) Mun *et al.* (1999) Echarte (2001) and Regulska and Ilow(2002).

Organoleptic evaluation

The average scores of sensory properties of cooked three species of fish by five cooking methods are shown in Table 6. It was proved that, the fillets cooked by broiled method for all species had the highest scores of taste, flavour, tenderness overall acceptability, followed by baking, deep frying, microwave and steaming methods, respectively. All fillets cooked by different methods were actually evaluated as "Good", while cooking by broiled method was as best as "Excellent" to tilapia fillets. These results are in good agreement with those reported by Guen *et al.* (2001).

From the results obtained it may be recommended that, the best consumption fish fillets (common carp, catfish and tilapia) was cooked by baking and broiling method, followed by deep frying, microwave and steaming methods, respectively.

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

	Whole body wt. (g)	Fork length (cm)	Fillet yield (%)
Common carp	650 – 2250 (1411)	32 - 41 (35)	39.5 – 46.1 (43.6)
Catfish	580 – 1250 (890)	35 – 47 (42)	403 – 45.7 (41.1)
Nile tilapia	190 – 280 (245)	10 – 16 (12)	38.1 – 45.3 (38.4)

Table 2. Mean ± standard error cooking yield (Y=percent) and cooking time (T=minutes) for fish fillets.

		Steamed	Baked	Broiled	Deep fried	Microwave
Common carp	Y	82.3±0.81 a	80.2±0.77 b	78.6±0.95 b	77.1±0.52 c	80.7±0.80 a
	T	21.2	15.6	12.0	3.9	1.4
Catfish	Y	84.0±0.57 a	78.8±0.83 b	78.0±0.55 b	77.3±0.47 bc	81.1±0.78 a
	T	16.0	12.3	9.3	3.0	1.1
Nile tilapia	Y	85.7±0.63 a	80.1±0.55 b	78.9±0.81 b	76.5±0.72 c	81.8±0.47 a
	T	11.5	9.1	6.5	2.1	0.9

$^{a-d}$ Means within a column with the same superscript significantly different ($P<0.05$).

Table 3. Proximate composition on a wet weight basis for raw and cooked fish fillets.

	Raw	Steamed	Baked	Broiled	Deep fried	Microwave
Moisture %						
Common carp	76.41	73.11	70.71	61.31	65.52	72.01
Catfish	78.00	74.20	71.60	71.40	67.00	73.00
Nile tilapia	78.50	74.40	72.20	71.90	66.70	73.30
Total solids %						
Common carp	23.59	26.89	29.29	29.69	34.48	29.99
Catfish	22.00	25.80	28.40	28.60	33.00	27.00
Nile tilapia	21.50	25.60	27.80	28.10	33.30	26.70
Lipid %						
Common carp	4.72	4.88	5.51	5.98	8.86	5.49
Catfish	2.51	3.72	4.80	4.91	6.82	4.38
Nile tilapia	1.85	2.55	3.37	3.91	6.20	3.10
Protein %						
Common carp	16.00	18.73	20.22	20.15	22.21	19.25
Catfish	17.32	19.42	20.75	20.83	23.51	19.91
Nile tilapia	18.03	20.54	20.95	21.75	24.38	21.05
Ash %						
Common carp	2.23	2.31	2.47	2.48	2.53	2.35
Catfish	1.52	1.68	1.80	1.86	1.92	171
Nile tilapia	1.30	1.52	1.61	1.64	1.70	1.55

Table 4. Mineral composition, wet weight basis, for raw and cooked fish fillets.

	Raw	Steamed	Baked	Broiled	Deep fried	Microwave
Sodium (mg/100g)						
Common	72.3	56.2	75.4	78.8	82.7	75.5
carp Catfish	58.1	45.2	60.1	63.2	66.5	60.1
Nile tilapia	64.0	50.3	66.3	70.1	73.2	67.3
Phosphorus (mg/100g)						
Common	252.5	220.3	273.1	281.8	312.3	276.6
carp Catfish	235.4	205.5	250.7	258.5	287.1	254.2
Nile tilapia	107.6	182.5	217.0	226.7	252.4	223.3
Calcium (mg/100g)						
Common	130.1	110.2	133.4	134.5	136.1	133.4
carp Catfish	81.50	72.70	82.10	84.40	87.00	82.70
Nile tilapia	125.3	110.4	127.3	129.3	131.5	128.0
Zinc (mg/100g)						
Common	0.44	0.42	0.47	0.48	0.59	0.48
carp Catfish	0.35	0.33	0.35	0.39	0.47	0.38
Nile tilapia	0.21	0.20	0.25	0.26	0.31	0.25
Iron (mg/100g)						
Common	0.26	0.24	0.28	0.30	0.37	0.28
carp Catfish	1.15	1.07	1.21	1.21	1.26	1.20
Nile tilapia	1.28	1.19	1.35	1.39	1.43	1.39
Copper (µg/100g)						
Common	39.3	35.4	40.0	42.3	46.0	40.1
carp Catfish	31.2	27.0	31.3	33.5	37.8	31.4
Nile tilapia	42.5	37.7	41.5	45.1	50.3	43.2

Table 5. Fatty acids composition of raw and cooked fish fillets and the sunflower cooking oil.

	Sunflower oil	Raw	Steamed	Baked	Broiled	Deep fried	Microwave
			Common carp				
C14:0	------	1.100	3.000	1.700	3.100	1.000	1.900
C16:0	9.500	26.03	22.61	20.84	19.06	15.41	22.09
C18:0	3.900	2.700	8.100	9.100	7.900	3.600	8.100
C20:0	0.700	1.650	1.100	0.710	1.700	0.200	1.500
C22:0	------	0.690	0.800	0.680	0.700	0.510	0.690
C23:0	0.370	0.610	0.720	0.650	0.650	0.550	0.600
C24:0	0.180	0.370	0.390	0.350	0.360	0.280	0.410
ΣSFA	14.65	33.15	36.72	34.03	33.47	21.55	35.29
C16:1	13.48	4.550	13.01	14.25	13.92	11.37	17.55
C18:1	68.31	33.32	17.70	16.25	17.81	25.52	16.81
C20:1	00.35	0.730	1.400	1.400	1.410	0.130	1.220
C22:1	------	0.210	6.400	7.900	4.530	1.820	5.200
ΣMUFA	82.14	38.81	38.51	39.80	39.67	38.84	40.78
C18:2	0.950	24.02	13.57	15.82	20.65	34.51	12.06
C18:3	0.620	1.710	8.400	8.450	5.710	3.010	10.37
ΣPUFA	1.570	25.73	21.97	24.27	26.36	37.52	22.43
U/S Ratio	5.710	1.950	1.650	1.880	1.910	3.540	1.790
			Catfish				
C14:0	------	0.100	2.100	0.970	3.660	------	0.810
C16:0	9.500	27.00	22.31	22.83	21.28	19.34	23.23
C18:0	3.900	7.600	11.01	11.76	10.15	9.850	11.52
C20:0	0.700	------	0.100	0.050	0.080	------	0.040
C22:0	------	0.800	0.510	0.410	0.380	0.800	0.730
C23:0	0.370	0.510	0.370	0.280	0.310	0.150	0.320
C24:0	0.180	0.220	0.050	0.080	0.050	0.210	0.110
ΣSFA	14.65	36.23	36.45	36.38	35.91	30.35	36.76
C16:1	13.48	8.100	11.66	12.64	12.62	6.220	13.65
C18:1	68.31	26.70	16.37	14.42	16.53	27.31	14.85
C20:1	00.35	2.200	1.510	1.570	1.810	1.000	2.110
C22:1	------	0.170	5.900	6.740	4.050	0.320	5.210
ΣMUFA	82.14	37.17	35.44	35.37	35.01	34.85	35.82
C18:2	0.950	21.10	16.05	16.94	19.72	32.60	14.27
C18:3	0.620	2.600	9.360	9.510	7.320	------	11.75
ΣPUFA	1.570	23.70	25.41	26.45	27.08	32.60	26.02
U/S Ratio	5.710	1.680	1.670	1.700	1.730	2.220	1.680
			Nile tilapia				
C14:0	------	3.100	5.730	4.490	6.460	2.600	3.800
C16:0	9.500	21.70	19.88	18.77	17.01	13.55	20.00
C18:0	3.900	5.000	6.450	7.530	7.230	4.100	7.490
C20:0	0.700	------	0.110	0.210	0.150	------	0.110
C22:0	------	0.400	0.220	0.510	0.350	0.210	0.150
C23:0	0.370	0.330	0.150	0.220	0.110	------	0.310
C24:0	0.180	0.510	0.250	0.440	0.510	0.330	0.610
ΣSFA	14.65	31.04	32.79	32.17	31.82	21.79	32.47
C16:1	13.48	2.100	11.38	12.18	12.08	7.530	15.52
C18:1	68.51	34.75	15.77	13.15	16.70	26.90	14.32
C20:1	00.35	0.200	1.120	1.130	1.210	1.800	1.220
C22:1	------	0.530	8.730	9.510	5.320	0.700	6.040
ΣMUFA	82.14	39.08	37.00	35.97	35.31	36.93	37.10
C18:2	0.950	23.30	16.36	18.05	20.91	39.08	15.54
C18:3	0.620	4.100	11.75	11.91	9.640	------	13.39
ΣPUFA	1.570	27.40	28.11	29.96	30.55	39.08	28.93
U/S Ratio	5.710	2.140	2.000	2.050	2.070	3.490	2.030

Table 6. Organoleptic evaluation of cooked fish fillets.

	Steamed	Baked	Broiled	Deep fried	Microwave
Taste					
Common carp	7.0±0.05 b (G)	8.5±0.03 a (VG)	8.8±0.05 a (VG)	8.0±0.07 a (VG)	7.0±0.04 b (G)
Catfish	7.0±0.05 c (G)	9.0±0.05 a (E)	9.0±0.04 a (E)	8.3±0.06 b (VG)	7.3±0.07 c (G)
Nile tilapia	7.5±0.06 c (G)	9.1±0.07 a (E)	9.5±0.03 a (E)	8.5±0.06 b (VG)	7.8±0.06 c (G)
Flavor					
Common carp	7.5±0.03 c (G)	8.5±0.05 b (VG)	9.0±0.06 a (E)	8.2±0.05 b (VG)	7.9±0.06 c (G)
Catfish	7.7±0.05 c (G)	8.5±0.04 b (VG)	9.2±0.06 a (E)	8.3±0.03 b (VG)	8.0±0.04 b (VG)
Nile tilapia	8.0±0.07 b (VG)	9.1±0.05 a (E)	9.5±0.06 a (E)	9.0±0.05 a (E)	8.5±0.05 b (VG)
Tenderness					
Common carp	8.2±0.07 a (VG)	7.3±0.05 b (G)	7.3±0.05 b (G)	7.5±0.07 b (G)	8.3±0.03 a (VG)
Catfish	8.3±0.06 a (VG)	7.5±0.03 b (G)	7.5±0.05 b (G)	7.5±0.06 b (G)	8.5±0.04 a (VG)
Nile tilapia	8.5±0.03 a (VG)	8.0±0.05 a (VG)	8.0±0.05 a (VG)	7.7±0.03 b (G)	8.5±0.03 a (VG)
Overall acceptability %					
Common carp	75.6±0.50 b (G)	81.0±0.43 a (VG)	83.7±0.53 a (VG)	79.0±0.63 b (G)	77.3±0.43 b (G)
Catfish	76.7±0.53 b (G)	83.3±0.40 a (VG)	85.6±0.50 a (VG)	80.3±0.50 a (VG)	79.3±0.50 b (G)
Nile tilapia	80.0±0.53 bc (VG)	87.3±0.63 ab (VG)	90.0±0.47 a (E)	84.4±0.47 b (VG)	82.6±0.47 b (VG)

a-c 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 المطهية بطرق مختلفة

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أجــرى هذا البحث لدراسة تأثير الطرق المختلفة لطهى الأسماك (السلق بالبخار، الشوى فى الفــرن، الشوى على الصاج، القلى والطهى فى الميكروويف) على التركيب الكيميائى ومحتواها من العناصر المعدنية والأحماض الدهنية وكذلك على الخواص الحسية لشرائح أسماك المبروك ،القراميط والــبلطى. حيث أوضحت النتائج أن سمك المبروك أعطى أكثر نسبة تصافى ٤٣,٦% وكذلك أطول فــترة طهى ٢١,٢ دقيقة بطريقة السلق بالبخار، بينما كانت أعلا محصلة للطبخ لشرائح سمك البلطى هي المطهية بطريقة السلق بالبخار مقارنة بجميع المعاملات الأخرى ٨٥,٧%.

أوضــحت النــتائج حــدوث زيادة تدريجية فى محتوى شرائح الأسماك المختلفة من الدهن، البروتيــن والرماد فى كل طرق الطهى، وأعلى معدل زيادة كان للشرائح المطهية بالقلى بينما حدث انخفــاض تدريجي للمحتوى الرطوبى للشرائح المطهية بالطرق المختلفة. كما أوضحت النتائج زيادة المحــتوى مــن العناصر المعدنية بطرق الطهى المختلفة عدا السلق بالبخار حيث حدث فيه انخفاض لجميع العناصر مقارنة بشرائح الأسماك الخام. انخفض المحتوى من الأحماض الدهنية أحادية وعديدة عــدم التشبع ونسبة الأحماض الدهنيه الغير مشبعة الى المشبعة لشرائح الأسماك المختلفة والمطهية بــأي طريقة طهى مقارنة بالشرائح الخام، عدا الطهى بالقلى حيث حدثت زيادة فى المحتوى من هذه الأحمــاض الدهنــية. كذلــك أظهــرت النتائج زيادة فى الأحماض الدهنية المشبعة لشرائح الأسماك المختلفة المطهية عدا الشرائح المطهية بالقلى حيث أدت إلى انخفاض المحتوى من الأحماض الدهنية المشبعة مقارنة بالشرائح الخام.

كمــا أظهــرت قــيم الخواص الحسية (الطعم، الرائحة، الطراوة والقابلية العامة) عدم وجود اختلافات معنوية بين شرائح الأنواع المختلفة المطهية بطريقة الشوى فى الفرن وعلى الصاج، حيث حصلت على أعلى ألقيم مقارنة بطرق الطهى الأخرى.

مــن نــتائج هذه الدراسة، يتضح أن افضل طرق استهلاك لشرائح اسماك المبروك العادى، القرامــيط والبلطى هي المطهية بطريقة الشوى فى الفرن اوعلى الصاج، القلى، الميكروويف، السلق بالبخار، على الترتيب.