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POLYCYCLIC AROMATIC HYDROCARBONS FORMATION IN COOKED TILAPIA FISH AND BEEF FINGERS AS AFFECTED BY COOKING METHOD AND SOME FOOD ADDITIVES

El-Badry, N.; M. Abu-El Fadl; A. M. Sharaf and M.H.El-Saied
Food Science and Technology Department, Fac. of Agric., Al-Azhar Univ., Cairo, Egypt

ABSTRACT

This research was carried out to threw the light on formation of polycyclic aromatic hydrocarbons (PAHs) in the cooked Tilapia fish and meat fingers (Kofta) as affected by the common cooking methods (electric- plate grilling and pan- frying for fish, and electric-max grilling ,charcoal grilling and pan-frying for meat fingers). In addition, the effect of some food additives (garlic paste or spices mixture) on the formation of the PAHs derivatives in cooked fish. Also, the most important quality criteria of Tilapia fish and meat fingers as affected by the former cooking processes and food additives treatment were investigated. The obtained results showed that thermal processing used in cooking caused a highly rise in the total PAHs content and encouraged the formation of the most determined PAHs derivatives at a considerable concentrations in fish flesh and meat fingers, especially charcoal grilling used in cooking of the second product. Treatments with either garlic paste or spices mixture prior to cooking caused a highly reduction in the total PAHs level at ratios of 67.45 and 58.06 % for grilled fish and of 60.50 and 44.83% of pan-fried ones; respectively, as well as preventing the formation of a lot of their derivatives. In addition, the other tested quality criteria (TBA, TVB-N, TMA-N, pH and WHC values) of Tilapia fish flesh and meat fingers were increased, except the last criterion, at different rates affecting by food product, pre-treatments, cooking method and the quality criterion itself. Therefore, the present results suggested that the fish and meat products should be treated prior to cooking and thermal processing with food additives treatment that causing inhibition or prevention the formation of the PAHs during cooking and also, it should be avoided cooking of meats by charcoal grilling which encouraged PAHs formation at a highly levels which causing the health hazard and cancer diseases.

INTRODUTION

Polycyclic aromatic hydrocarbons (PAHs) constitute a large class of organic compounds containing two or more fused aromatic ranges made up to carbon and hydrogen atoms. Hundreds of individual PAH may be formed and released as a result of incomplete combustion or pyrolysis of organic matter, during industrial processes and other human activities .the PAH are also formed in natural processes such as carbonization *(FAO/ WHO, 2005)*.

Benzo(a) pyrene (BaP), a member of the PAH class, is one of the most potent PAH carcinogens in animal experiments, and its relatively easy to separate and analyze. BaP is present in a wide variety of food items, it has been chosen as the general indicator of total PAHs presence in processed foods *(Kazerouni, et. al., 2001and Simko, 2002)*. The emission factors of total PAHs , BaP for broiling meat were noticeably higher than those for broiling vegetables and non –fish seafood *(Kuo, et. al. 2006)*. It had been reported that the PAHs are mutagenic and carcinogenic agents in animals and human Polycyclic aromatic hydrocarbons which formed in processed and cooked foods are very well known ecotoxicants which are harmful health. In mammalian cells PAH undergo metabolic activation to diol epoxides that bind covalently to cellular macromolecules, including DNA, thereby causing errors in DNA replication and mutations that initiate the carcinogenic process (Janoszka, et al.2004).As there is no comprehensive PAH database , epidemiologic studies have not been able to estimate dietary PAH intake and investigate the risk of cancer associated with it. However, investigators have evaluated the relationship between the intake of several foods that may have high level of PAH (e.g. smoked or grilled / barbecured meats)and risk for cancer at several sites including stomach and esophagus , colorectal, pancreatic and bladder cancer (Steineck,et al,1990) . Because PAH are contained in wide variety of food , it is necessary to directly estimate the dietary intake of BaPfrom all dietary sources to evaluate the relationship between dietary intake of BaP and risk of cancer.

Food can be a source of the PAH , although these compounds can be taken up from the environment, i.e. from water, soil, and air and can be accumulated in plants, fruits vegetables, grains , fats, meat and seafood, and in food during its transport and storage. Also, they are primarily formed as a result of thermal treatment of food *(*Janoszka *et al., 2004).*When food, particularly meat, meat products and fish is smoked, roasted. fried and grilled, the PAHs are formed as a result of incomplete combustion or thermal decomposition (pyrolysis) of the organic material. It had been reported that grilling, frying or roasting would generate PAHs in cooked meat and charcoal grilling gave rise to the highest amount of PAHs when compared with frying, gas grilling or electric oven roasting. Grilling of meat at a lower temperature or further away from the heat source would result in lower level of PAHs

If the meat is in direct contact with the flame , pyrolysis of the fats in the meat generates PAHs that can become deposited on the meat. Even it not in direct contact , fat dripping on the flame or hot coals generates the compounds which are then carried back on to the meat .PAH production by cooking over charcoal is a function both of the fat content of the meat and the proximity of the food to the heat source, and can be reduced by cooking for longer period at lower temperature. Charred food of almost any composition with containing PAHs, however, normal roasting or frying food does not produce copious quantities of PAHs . Also the food is low in fat or cooked beneath the source of heat, contain many fewer PAHs , so the type of food cooked and the method of cooking are important *(Howord and Fazio, 1980;Felton and Knize, 1991; Sinha and Rothman, 1999).*

The main targets of this research are to study the effect of the common cooking methods (grilling and pan-frying) and the treatments with some food additives (garlic paste and spices mixture),prior to cooking, on the formation of polycyclic aromatic hydrocarbons (PAHs) in Tilapia fish and meat fingers (Kofta). Also, the most important quality criteria (TBA, TVB-N, pH and WHC values) of the former tested two products as affected by chosen cooking methods and food additives treatments were investigated to evaluate the cooking methods which prevent or reduce the PAHs formation in the tested foods.

MATERIALS AND METHODS

Materials:

Fish samples: Fresh water Tilapia (Oreochromis niloticus) fish were obtained from the local market at Mataryia region, Cairo, Egypt, then transferred in ice-box to the laboratory. Then, they prepared and analyzed.

Meat samples: Lean meat was obtained from butcher shop in Mataryia local market, Cairo, Egypt. Packaged in polyethylene bags, and then kept at refrigerator for one day until used and analyzed.

Refined sunflower seed oil: The refined sunflower oil, which produced on June, 2006 was obtained from the Cairo Co. for Oil and Soap, Giza, Egypt.

Garlic and onion: They were obtained from the local market at Mataryia region, Cairo, Egypt, whereas, the garlic paste were prepared by grinding the decoated garlic lobes.

Sodium chloride: It was obtained from the Egyptian Salts and Minerals, Co., Egypt.

Spices: spices (cumin, coriander and black pepper) were obtained from the local market at Nasr city, Cairo, Egypt. The spices were cleaned individually and ground to a fine powder. The spices mixture was prepared by mixing equal weight from the former spices and then mixed again carefully .

Methods :

1- Preparation of fish samples : Tilapia fish samples were eviscerated and washed with tap water .The cleaned fish samples were immersed in 10 % NaCl solution for 10 min and then washed with tap water and divided into three equal parts. Each part was consisted of six fishes , each weighed 230-270 gm .The first part was used as control which untreated with any food additives treatment , while the second and third parts were mashed with either garlic paste or spices mixture .Each part was divided into two portions one of them thinly coated with wheat flour (72% extraction) and then was cooked by pan –frying and the another was coated with wheat bran and then cooked by electric – plate grilling.

2- Preparation of meat fingers : Lean meat sample (3kg) was ground by meat grinder, and mixed with anther ingredients tabulated in table (1) as follow:

Table (1): the formula used for meat Fingers (Kofta) preparation

Ingredients	Amount (g)
Ground meat	1000
Onion	100
Eggs	100
Salt (sodium chloride)	10
Ground toast	40
Black pepper	4

All ingredients were mixed well again ,and then meat finger (kofta) were made manually as shape like-fingers as the method described by *Janoszk et al.(2004)* and *Anon (1996)* and divided into three approximately equal parts ,each weighed about 1 kg .The first part was cooked by electric grilling , while the second part was cooked by charcoal grilling and the third part was cooked by pan – frying .

3- Cooking methods:

3.1- pan-frying method: In pan-frying, 250 gm of refined sunflower seed oil placed in stainless shallow pan and firstly heated at 160±5°C, then the prepared fish samples were fried at 160°C for 8 min (4 min for each side), and also the meat fingers (Kofta) were fried for 5min. After frying all fried samples were allowed at ambient temperature until they had cooled.

3.2-Grilling method: Prepared fish samples were grilled on a laboratory electric- plate grill (Model Suteskv, Russia), size of the flat was (30x30 cm). The fish samples were grilled at 160°C for 6 min for the first side and then turned over to cook the other side for 6 min. While prepared meat fingers (Kofta) were grilled either on electric grill (Max grill, 200-230V, 2000W, 50-60Hz, made in turkey) for 10 min or on manual grill-type fuelled with burnt charcoal for 15 min, according to the procedure of *Janoszka et al. (2004)* The grilled, fried fish flesh and beef Kofta samples were ground and homogenized by grinder (Oster Heavy Duty Food Grinder, USA) and packed in polyethylene bags and stored under freezing condition at -18±2°C until analyzed (*Gall et al., 1983*).

4- Analytical methods:

4.1- Total Volatile base- Nitrogen (TVB-N): and Trimethyl amine nitrogen (TMA-N) were determined according to the method described by (Pearson, 1976).

4.2 -Thiobarbituric acid (TBA) value: The TBA value was determined directly on the samples as described by Egan et al. (1987).

4.3 - pH value: It was determined according to the method described by Hood (1980).

4.4 -Water Holding Capacity (WHC): The WHC values in minced fish and meat finger sample were measured according to the method described by Soloviev ,(1966).

4.5 -Polycyclic Aromatic Hydrocarbons(PAHs):

1-Extraction: The PAHs were extracted according to the method described by Howared et al.(1966 a and b) with slight modification carried out by Egyption Petroleum Research Institute ,Ministry of Scientific Research ,Egypt. In brief, each sample was digested in alcohol and potassium hydroxide and then distilled water was added and the hydrocarbons partitioned into iso octane . Interfering materials were removed by column chromatography on florisil (60-100 mesh) followed by selective extraction of the PAH into dimethyl sulfooxide (DMSO).Further interfering materials were removed by column chromatgraphy on Sephadex LH-20, utilizing a solvent mixture of toluene and ethanol at ratio of 1:1 to obtained the purified extracts of the PAH which used for determination of the PAH components.

2-Determination : The 16 individual PAHs listed by the reference reported by the United States (US-EPA),in the purified extracts of tested samples were determined qualitavely and quantitively by using high performance liquid chromatography (HPLC) according to the procedure described by *Lal and Khanna,(1996)*. The PAHs identification and system with millennium 3.2 software PAHs standard were obtained from quantification performed using HPLC.The apparatus model used in determenation was waters HPLC 600 E,equipped with dual UV absorbance detector water 2487 and auto samplers 717 plus attached to computerized supelco.The condition of separation is as follow:

Column: Supelcosil LC-PAH,5µm particles 15 cm length and 4.6 mm ID.

Mobile Phase: Graient acetonitrile;water 60 to 100% acetonitrile (v/v)over 45 min.

Flow rate :0-2 min,0.2 m/min,2-45 min.1.0 ml/min.

Detector: It was set at 254 nm.

RESULTS AND DISCUSSION

1-The effect of cooking method and some food additives on formation of polycyclic aromatic hydrocarbons (PAHs) in cooked Tilapia fish:

Sixteen PAHs compounds were determined in raw and cooked Tilapia fish samples including ; naphthalene (NA), acenaphthylene (ACL), acenaphthene (AC), fluorine (FL), phenanthrene (PHE), anthracene (AN), fluoranthene (FA), pyrene (PY), benzo(a)anthracene (BaA), chrysene (CHR), benzo(b)fluoranthene (BbFA), bonzo(k) fluoranthene (BkFA), benzo(a)pyrene (BaP), dibenzo(a,h)anthracene (DBahA), benzo(g,h,i)pyrene (BghiP) and indeno(1,2,3-cd)pyrene (IP). And the results are given in Table (2).

As shown in table (2), raw Tilapia fish muscles contained any compounds of the determined sixteen PAHs with the exception of the IP compound which was found in the level of 0.6225 µg /kg. Table (2) also indicated that thermal processing used in food cooking facilitated the formation of the most identified PAHs in fish muscles at different rates affecting by cooking method and pre-treatments with food additives. Whereas, the total PAHs were increased from 0.6225 µg /kg raw fish flesh to 11.5112 and 8.5099 µg /kg for grilled and pan-fried fish samples; respectively. In addition, ACL, AC, FL, PHE, AN, FA, PY, CHR and BaP compouned were formed at a considerable concentrations in fish samples after the two applied cooking methods, in addition to the formation of both BkFA and IP in grilled fish and of both BaA and DBahA in pan-fried fish sample. These results are in accordance with those found by Phillips (1999) and Anderson et al. (2002), who reported that electric-plate grilling or frying would generate PAHs in cooked meat and fish, especially throughout the first cooking method which cause a highly rise in the formation of carcinogenic PAHs due to the direct contact of foods with the heat source leading to generate PAHs at a higher extent than the second one , as the result of incomplete combustion and pyrolysis of organic matter including proteins and fats.

With regards the PAHs formation in cooked Tilapia fish as affected by food additives (Table 2), treatments with spices mixture or garlic paste caused, in general, a highly inhibition of forming the tested PAHs in grilled and pan-fried fish samples at a variable rates depending upon pre-food additive treatment, cooking method and the PAHs component itself; these treatments caused a highly considerable reduction in total PAHs at ratios of 67.45 and 58.06 % for grilled fish and of 60.50 and 44.83 % for pan-fried ones; respectively. However, spices mixture treatment caused prevention the formation of ACL, AC, FL, and CHR components in grilled fish and of AC, CHR and DBahA compounds in pan-fried fish, as well as the reduction of other PAHs formation extent in cooked samples, when compared with the control samples (untreated with additives). In addition, garlic treatment inhibited or prevented the formation of components in cooked fish samples. The inhibition effect of spices and garlic treatment on the formation of the PAHs in cooked fish may be due to the naturally occurrence antioxidant in them which are prevented or inhibited the oxidation and polymerization of hydrocarbons resulted from incomplete compusition and pyrolysis

Table (2): The effect of cooking method and some food additives on formation of polycyclic aromatic hydrocarbons in cooked Tilapia fish

Pretreatment / PAHs compounds	PAHs components level (µg/kg)						
	Raw fish	Grilled fish			Fried fish		
		Contol (without additives)	Spices	Garlic	Contol (without additives)	Spices	Garlic
Naphthalene	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	ND	1.0661	ND	0.0746	2.0295	0.0140	0.8863
Acenaphthene	ND	0.0758	ND	0.0034	0.8518	ND	0.0442
Fluorene	ND	1.1426	ND	0.0101	2.8010	0.0145	1.2701
Phenanthrene	ND	0.4022	0.0011	0.0052	0.2784	0.1238	01618
Anthracene	ND	1.6422	0.0005	0.0013	0.0787	0.0448	0.0408
Fluoranthene	ND	0.9209	0.0001	0.0013	0.1989	0.0830	0.1315
Pyrene	ND	0.3041	0.0010	0.0288	0.9581	0.0356	0.7436
Benzo(a)anthracene	ND	ND	ND	ND	0.1829	0.0211	ND
Chrysene	ND	0.2483	ND	0.0031	0.4087	ND	ND
Benzo(b) Fluoranthene	ND	ND	ND	0.0205	ND	0.0212	ND
Bezo(k) Fluoranthene	ND	0.6848	0.0002	0.0040	ND	ND	0.0648
Benzo(a)pyrene	ND	0.3826	0.0725	0.0918	0.2116	.00261	0.0425
Dibenzo(a,h) nthracene	ND	ND	ND	ND	0.5103	ND	0.9368
Benzo(g,h,i)pyrene	ND	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd) pyrene	0.6225	4.8949	3.6712	4.5827	ND	2.9770	0.3717
Total PAHs	0.6225	11.5112	3.7466	4.8268	8.5099	3.3611	4.6941

2- PAHs formation in cooked meat fingers (Kofta) as affected by cooking methods:

As illustrated in Table (3); NA, ACL, AC, FL, CHR, BaP and BghiP compounds were not detected in raw meat fingers which contained a low level (0.3421 µg/kg) of total PAHs as well as a negligible concentrations from the determined 9ndividualPAHs.

Conceming the formation extent of the PAHs in cooked meat fingers (Kofta) as given in Table (3), the tested cooking processes facilitated the formation of PAHs in meat fingers at a much higher extent when compared with raw uncooked sample. On the other hand, charcoal grilling caused a much higher formation of the PAHs in cooked meat fingers than those cooked by either electric-plate grilling or pan-frying, especially the carcinogenic IP, PHE, BaP, PY and CHR compounds which were formed in charcoal grilled meat fingers at a much higher levels than those cooked by other methods. Whereas, Kofta samples cooked by charcoal grilling, electric-max grilling and pan-frying had 25.5, 17.2 and 14.6 folds of the raw uncooked sample; respectively.

The obtained data (Table 3) also showed that FA, BbFA, kFA and BahA compounds in electric-max grilled samples and PY, BbFA, BaP and DBahA in pan-fried samples were not detected after cooking. Also, NA compound was not detected in grilled fish samples, while it appeared in pan-fried samples, in contrary to IP compound.

Table (3): The polycyclic aromatic hydrocarbons (PAHs) formation in meat fingers (Kofta) as affected by cooking methods.

Pre treatment / PAHs compounds	PAHs components level (µg/kg)			
	Raw meat fingers (uncooked)	Cooked meat fingers (Kofta)		
		Plate-grilling	Charcoal-grilling	Pan-frying
Naphthalene	ND	ND	ND	0.1591
Acenaphthylene	ND	0 9237	ND	3.3966
Acenaphthene	ND	0 1485	ND	0.7820
Fluorene	ND	0.3207	0.1670	0.0356
Phenanthrene	0.0027	0.7883	0.8423	0.3226
Anthracene	0.0003	0 1163	0.2305	0.0519
Fluoranthene	0.0001	ND	0.0596	0.0773
Pyrene	0.0034	0.9072	0 3810	ND
Benzo(a)anthracene	0.0008	0.1524	ND	0.0669
Chrysene	ND	1.0941	0.3422	0.0810
Benzo(b) Fluoranthene	0.0021	ND	0.1520	ND
Bezo(k) Fluoranthene	0.0003	ND	0.1162	ND
Benzo(a)pyrene	ND	0.0146	1.0941	ND
Dibenzo(a,h) anthracene	0.0020	ND	0.4573	ND
Benzo(g,h,i)pyrene	ND	ND	ND	ND
Indeno(1,2,3-cd) pyrene	0.3304	1.4072	3.5443	ND
Total PAHs	0.3421	5.8772	8.3865	4.9730

The highest extent of the PAHs formation in charcoal grilled meat kofta could be interpreted as when food, particularly meat, is cooked over hot coals, the PAHs are formed. If the meat is in direct contact with the flam or hot coals, pyrolysis of the meet fats generates PAHs than can become deposited on the meat. Even if not in direct contact, fat dripping on the hot coals generates the PAH compounds which are then carried back on to the meat product, and therefore, the PAHs formation by cooking over charcoal is a function both of the fat content of meat product and the proximity of food to the heat source (Lijinsky, 1991; Phillips, 1999 and Kuo et al.,2006).

3-The limitations of polycyclic aromatic hydrocarbons (PAHs) in food and the daily intake of some carcinogenic PAHs based on consumption of 250 gm from the tested cooked Tilapia fish and meat fingers products (kofta).

Until now, the maximum permissible level and the health hazard dietary intake of the PAHs in cooked and processed food are undefinite accurately and varied from country to another. In this concern, Janoszka et al. (2004) mentioned reported that the health hazard level of the PAHs daily ingested in the diet was found to be 3.7 µg in great Britain, 5.17 µg in Germany, 1.2 µg in New Zealand and 3µg in Italy. Also, FAO/WHO., (2005) reported that total PAHs level of 14µg/kg in cooked and processed foods considered to be carcinogenic and mutagenic.

With regards the carcinogenic PAHs predominated in studied cooked fish and meat products, were BaP, ACL and FL. In addition, the BaP compound had been reported as a good general indicator of the formation level of total PAHs in cooked and thermal processed fish and meat products and that compound represented 1-20% of total PAHs in the former thermal-treated products (Kazerouni et al., 2001and Simko,2002). It has been reported that the maximum permissible levels (MPLs) of total PAHs and BaP are 1 and 10 µg/kg wet cooked or processed meat and fishery products; respectively(FAO/WHO,2005). While, the MPL of 2 µg/kg of ACLor FL in the formed kinds of food had been reported by Stolyhwo and Sikroski (2005).

The healthy safe quality of the tested cooked fish and meat fingers was evaluated in relation to the most considerable limitation of carcinogenic PAHs and possible daily intake of these compounds and some their derivatives with consumption of 250g of the tested cooked foods.

Table (4): The limitation of PAHs in food and the daily intake of some carcinogenic PAHs based on consumption of 250 gm from the tested cooked fish and meat products.

Cooked sample	Total PAHs		BaP		ACL		FL	
	Content (µ/kg)	Daily intake* (µ/kg)	Content (µ/kg)	Daily intake* (µ/kg)	Content (µ/kg)	Daily intake* (µ/kg)	Content (µ/kg)	Daily intake* (µ/kg)
Electric-plate grilling fish								
Without additives	11.5112	2.8778	0.3826	0.0957	1.0661	0.2665	1.1426	0.2857
With spices mixture	3.7466	0.9366	0.0725	0.0181	ND	-	ND	-
With garlic paste	4.8268	1.2067	0.0918	0.0230	0.0746	0.0187	0.0101	0.0025
Pan-fried fish								
Without additives	8.5099	2.1274	0.2116	0.0529	2.0295	0.5074	2.8010	0.7003
With spices mixture	3.3611	0.8403	0.0261	0.0065	0.0140	0.0035	0.0145	0.0036
With garlic paste	4.6941	1.1735	0.0425	0.106	0.8863	0.2216	1.2701	0.3175
Cooked meat finger								
Electric-max grilled	5.8772	1.4693	0.0146	0.0037	0.9237	0.2309	0.3207	0.0802
Charcoal grilling	8.3865	2.0966	1.0941	0.2735	ND	-	0.1670	0.0418
Pan-fried	4.9730	1.2433	ND	-	3.3966	0.3492	0.0356	0.0089
Carcinogenic level (µ/kg)	14.0		≤ 2		-		-	
Health hazard (µ/day)	5.7		< 1		< 2		< 2	
Maximum permissible level (µ/kg)	10.0		1		2		2	

*** Daily intake(µg) based on consumption of 250gm of product per day**

As illustrated in Table (4), the fish samples should be treated with spices mixture and garlic pasta perior to cooking process, to avoid the formation of the PAHs in cooked fish at carcinogenic level or at the healthy hazard level. Also, it should be avoided the cooking of meat products by charcoal grilling method which this encourages the formation of PAHs and their derivatives at a higher levels which causing health hazard and cancer diseases and should be tried to find the best pre-treatments that prevent or inhibit the PAHs formation throughout thermal processing and cooking.

4-The effect of cooking method and some food additives treatment on some important quality criteria of Tilapia fish.

It is well known that there are many atterations possible occurred in the most important quality criteria (TBA,TVB-N,TMA-N,pH .and WHC values) of fish flesh affected by cooking method and food additives treatment and by the polycyclic aromatic hydrocarbons (PAHs) formed in fish products throughout thermal processes and cooking method .Therefore ,the former quality criteria of Tilapia fish as affected by some food additives (spices mixture and garlic paste) and the common cooking methods (electric- max grilling and pan – frying) were investigated ,and the obtained results in presented in Table (5).

Table (5): The effect of cooking method and some food additives treatments on some important quality criteria of Tilapia fish

Treatments	Quality criteria				
	TBA value	TVB-N content (mg/100g)	TMA-N content (mg/100g)	pH value	WHC ($cm^2/0.3g$)
Raw fish	0.086	11.02	1.39	6.46	7.71
Grilling cooking					
Without any additives	0.191	14.73	2.36	7.02	6.99
With spices treatment	0.125	13.18	2.01	6.93	6.57
With garlic treatment	0.140	12.29	2.14	6.87	6.13
Pan-frying cooking					
Without any additives	0.233	12.86	1.96	6.79	7.24
With spices treatment	0.177	12.09	1.70	6.60	7.15
With garlic treatment	0.189	11.74	1.58	6.51	6.90

From Table (5), it could be observed that the TBA value, the TVB-N and TMA-N contents , the pH and the WHC value of raw uncooked Tilapia fish muscles were found to be 0.086 mg malonaldehyde /kg, 11.02mg/100g, 1.39mg/100g, 6.46 and 7.71cm^2/0.3g, on wet weight bases; respectively.

Results in Table (5) also cleared out that thermal processes used in tested cooking method, in general, caused highly increase in the TBA value of fish as a successful criterion for the secondary oxidation of lipid, at different rates affecting by cooking method and food additives treatment, in accordance with these by Seet and Browen, (1983). Electric –plate grilled fish samples had a lower TBA values than the corresponding samples cooked by pan-frying. This observation may be due to the lower content of fat as the result of dripping and to the higher polycyclic aromatic hydrocarbons (PAHs) levels, which having antioxidant properties, in the first kind of fish samples. In addition, treatment prior to cooking with either spices mixture or garlic paste resulted in inhibition the oxidative rancidity of fish lipids throughout cooking process. Nevertheless, the elevation in the TBA values of cooked fish, these values were much lower than the critical value (10 mg malonaldehyde / kg) after which the fish lipid might be completely oxidized and should not be used for human consumption (Greene and Cumuze, 1982 and Anon, 1994*)*

With regards the TBV-N and the TMA-N contents , as shown in table (5), the values of both criteria of Tilapia fish were increased after cooking by either electric- plate grilling or pan-frying, especially with the first method. Such increment in the values of the former quality criterion in cooked fish could be attributed to the thermal breakdown of fish protein and conversion some nonvolatile compounds to the volatile form throughout cooking treatments *(Chia et al.,1983 and Khallaf, 1990).* Also, the obtained data revealed that pre-treatment with either spices mixture or garlic paste cause a reduction of the destruction rate of fish protein during cooking; this effect may be attributed to the protective effect of the aromatic compounds naturally occurred in the former additives on fish protein molecules resulting in inhibition of their destruction throughout thermal processing. Also, the obtained data (Table 5) indicated that the pH values of all cooked fish samples were higher than those of raw uncooked fish sample as the result of thermal cooking effect on fish protein breakdown, resulting in a formation of some free dibasic amino acids and some volatile basic compounds as previously explained *(Pirazzoli et al., 1986* and *Abd-Elghafour, 2004).* Furthermore, the treatment with either spices mixture or garlic paste prior to cooking caused the reduction of the pH values of fish samples after cooking by electric-plate grilling or by pan-frying, as the result of the inhibition effect of the naturally occurred aromatic compounds in the former food additives on formation of volatile basic compounds as previously mentioned.

From the above data (Table 5), it could be also observed that water holding capacity (WHC) of Tilapia fish samples was decreased after cooking by either electric-plate grilling or pan-frying. This alteration may be due to the influence of thermal cooking which causing the reduction of moisture content as well as denaturation and destruction of fish protein *(Wahdan,1992 and Abd-Elghalfour,1999).* The spices mixture or garlic paste treatments caused slight decrease in water holding capacity of fish samples after plate-grilling and pan-frying; that might be attributed to the activation of the aromatic compounds present in garlic and spices on fish protein configuration and function.

5-The most important quality criteria of meat fingers (Kofta) as affected by cooking methods.

The effect of common methods (electric-max grilling, charcoal grilling and pan-frying) on the most important quality criteria of meat fingers (kofta) including; the TBA,the TVB-N, the TMA-N,the pH and the WHC values were investigated and the obtained results are recorded in Table (6).

From the results in Table (6), it could be observed that the TBA value, as a good criterion for the secondary oxidation of lipids, of meat fingers was highly raised after their cooking by either electric-max grilling, charcoal grilling or pan-frying, whereas the highest increasing rate in this value was observed in meat fingers cooked by pan-frying, due to the higher oxidation rate was taken place in meat fat and pan-frying oil medium, while the lowest value was found in those cooked by charcoal grilling due to the antioxidant effect of polycyclic aromatic hydrocarbons(PAHs) resulted from pyrolysis of the fats in meat fingers that can become deposited on them and from fat dripping on to the hot coal which are then carried on to the meat product (Phillips, 1999 and Kuo et al., 2006).

With regards the TVB-N and the TMA-N contents in cooked meat fingers as shown in Table (6), all chosen cooking methods, in this study, caused an increase in both TVB-N and TMA-N contents of meat Kofta at different rates depending upon the cooking method conditions. Whereas, grilling methods were more effective in causing

Table (6): The most important quality criteria of meat fingers (Kofta) as affected by cooking methods

Treatments	Quality criteria				
	TBA value	TVB-N content (mg/100g)	TMA-N content (mg/100g)	pH value	WHC (cm^2/0.3g)
Raw uncooked meat fingers (Kofta)	1.159	15.26	2.03	7.10	9.47
Grilling					
Electric-max grilling	2.082	17.54	2.39	7.33	8.02
Charcoal grilling	1.636	18.19	2.57	7.41	7.86
Pan-frying	2.970	16.82	2.19	7.26	8.13

this increment alteration, especially charcoal grilling which resulted the highest contents of the two quality criteria of cooked meat fingers. Such increase in the values of these criteria in cooked meat product could be attributed mainly to the influence of thermal treatments used in cooking methods on the destruction of meat fingers protein leading to form some volatile basic compounds (Pirazzoli et al.,1986 and Abd-Elghafour, 1999). It is worth to mention that, the TVB-N and TMA-N values of all cooked meat fingers were much less than the critical permissible levels (30 and 10mg/100g sample, respectively) reported by Anone, (1999).

Concerning the tested physical quality criteria, the pH value of meat fingers was increased after cooking by eiather the two kinds of grilling or pan-frying, especially with charcoal grilling as the result of a higher extent of polycyclic aromatic hydrocarbons (PAHs) formation. However, the increase in the pH value of cooked meat fingers could be attributed mainly to the protein destruction of meat product by the thermal cooking treatments, resulting in a formation of some free dibasic amino acids and other basic derivatives as interpreted by Khallaf (1990). On the other hand, the water holding capacity (WHC) of meat fingers was decreased after cooking by either electric-max grilling, charcoal grilling or pan-frying, whereas the lowest WHC value was observed in charcoal grilling sample. This alteration may be related mainly to the destruction and denaturation of meat fingers protein by the thermal treatments used in cooking processes, resulting in the diminution of protein solubility.

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تكوين المركبات الهيدروكربونية العديدة الحلقات في سمك البلطي وكفتة اللحم البقرى المطهية ومدى تأثرها بعمليات الطهي وبعض الإضافات الغذائية

ناصر البدرى عبد اللاه – مصطفى أبو الفضل محمد– أشرف محمد شرف– محمد حمزه السعيد
قسم علوم وتكنولوجيا الأغذية-كلية الزراعة – جامعة الأزهر– القاهرة

أجرى هذا البحث لإلقاء الضوء على تكوين المركبات الهيدروكربونية العديدة الحلقات– المسببة لبعض الأضرار الصحية للمستهلك للأغذية التي تحتويها– في سمك البلطي وأصابع اللحم البقرى (الكفتة) المطهية ومدى تأثرها بطرق الطهي المختبرة و بعض الإضافات الغذائية. كما اشتملت الدراسة على تقييم بعض دلائل الجودة الهامة في تلك الأغذية ومدى تأثرها بمعاملات ما قبل الطهي وكذا الطرق المستخدمة في طهيها. وقد أوضحت النتائج المتحصل عليها أن المعاملات الحرارية المستخدمة في طهي سمك البلطي و كفتة اللحم البقرى قد أدت إلي حدوث ارتفاع كبير في محتواها من المركبات الهيدروكربونيه العديدة الحلقات خاصة طريقه الشي علي الفحم المشتعل المستخدمة في طهي كفتة اللحم البقري كما أدت معاملة سمك البلطي بكلاً من عجينة الثوم أو مخلوط التوابل قبل عملية الطهي بالشي أو القلي السطحي إلي انخفاض محتواها الكلي من تلك المركبات الحلقية بمعدل ٦٧,٤٥، ٥٨,٠٦ % في العينات المطهية بالشي و ٤٤,٨٣، ٦٠,٥٠% في العينات المطهيه بالقلي علي الترتيب. كما أظهرت النتائج المتحصل عليها أيضا أن دلائل الجودة (رقم حامض الثيوباربتيوريك والقواعد النيتروجينيه الطيارة و مركب الثلاثي ميثيل أمين)لسمك البلطي وكفتة اللحم البقري قد ارتفعت بمعدلات متباينة نتيجة اختلاف نوع الغذاء ومعاملات ما قبل الطهي وطريقة الطهى المستخدمة.

لذا فأن نتائج هذه الدراسة توصى بمعاملة الأسماك واللحوم ومنتجاتها ببعض الإضافات الغذائية أو بأي معاملة أخرى قبل الطهى قد تؤدى إلى منع أو تثبيط تكوين المركبات الهيدروكربونيه العديدة الحلقات أثناء طهيها وتجنب طهي اللحوم بطريقة الشى على الفحم المشتعل لأنها تؤدى إلى تكوين تلك المركبات بمستويات قد تصل أو تفوق التركيزات المسببة للأضرار الصحية والإصابة بأمراض السرطان.