

## Quality attributes of coated tilapia fillets as affected by some spices and their volatile oils during storage at -18°C

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### Abstract

This study was carried out to evaluate the proximate composition, chemical, physical, and sensory properties of uncooked and semi-fried coated tilapia fillets manufactured by using two spices powder mixtures i.e., garlic and cumin mixture (GC) and garlic and parsley mixture (GP) and their volatile oils mixtures during frozen storage at -18°C for 3 months. The proximate composition of coated tilapia fillets was not affected ( $p > 0.05$ ) by the type (GC or GP) and form of additives (volatile oils or spices powder) but was significantly affected by cooking process and frozen storage period at -18°C. Coated tilapia fillets prepared without additives had significantly higher total volatile base nitrogen (TVBN), trimethyl amine (TMA), thiobarbituric acid (TBA), pH, water holding capacity values (worst WHC) and cooking loss than tilapia fillets coated with different additives. Also, spices volatile oils mixtures were more effective than spices powder mixtures on reduction of TVN, TMA and TBA values. Semi-frying process led to significant decrease moisture content, TVN, TMA, water holding capacity value (best WHC), plasticity and cooking loss and significantly increased crude protein, crude fat, total ash, carbohydrates contents, TBA and pH values. The crude fat, total ash, carbohydrates, TVB.N, TMA, TBA, pH and cooking loss values of coated tilapia fillets were significantly increased by frozen storage period increment. However, moisture content, crude protein content, water holding capacity (i.e., separated free water increased) and plasticity were significantly decreased with advancement of frozen storage. The sensory properties of coated tilapia fillets prepared with volatile oils had rating described as like very much (7.48-8.22). However, coated tilapia fillets prepared with spices mixtures powder had rating described as like moderately (6.85) and like very much (7.14 -7.64). The sensory properties of uncooked 6.70-8.17) and semi fried (6.72-7.63) coated tilapia fillets had rating described as like moderately to like very much.

**Keywords:** Coated tilapia fillets, semi frying, spices powder, volatile oils, cumin, Garlic, Parsley.

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### 1. Introduction

Fish has an important role in human food consumption. Fish is generally acknowledged as a highly nutritious food due to its contribution of high quality animal protein as well as its richness in calcium, iron, copper and phosphorus and generous supply of vitamins beside their high palatability and digestibility. Fish lipids have also been assumed to have great nutritional significance because of their high polyunsaturated fatty acid (PUFA) levels (Puwastien *et al.* 1999). The PUFA can reduce blood low density lipid cholesterol and have antithrombotic, anti-inflammatory and antiarrhythmic properties (Lombardo and Chicco 2006). Hence, PUFA may help prevent coronary heart disease, hypertension, type 2 diabetes and insulin resistance (Zhang *et al.*, 2012).

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Cold storage and freezing are the normally employed methods for fish preservation, but they do not completely inhibit microbial and chemical reactions that lead to quality deterioration of fish (Jeon, *et al.*, 2002). Moreover, fish and its products can undergo undesirable changes during frozen storage that lead to deterioration which may limit their storage time. These undesirable changes result from protein denaturation (Benjakul *et al.*, 2005) and lipid oxidation (Richards and Hultin, 2002 and Osheba *et al.*, 2013). The use of some synthetic food additives has been questioned due to possible toxic and carcinogenic effects on human health. Several countries have restricted the use of chemical additives that are harmful to human health (Samojlik *et al.*, 2010). Hence, consumers now prefer natural food additives over traditional synthetic preservatives (Calo *et al.*, 2015).

Spices and herbs have been added to food not only as flavoring agents but also as folk medicine and food preservatives. Certain spices and herbs were used as green materials, plant extracts; essential oils (EOs) and powders for enhancing the storage life of foods by preventing rancidity through their antioxidant activity or bacteriostatic or bactericidal activity, also to foodborne pathogenic bacteria (Singh *et al.*, 2005). Essential oils of garlic, cumin and parsley could represent a promising option since numerous studies have confirmed their antioxidant (Nurwantoroa, *et al.*, 2015; Al-Shawi *et al.*, 2017 and Farouk *et al.*, 2017) and antimicrobial (Karimi *et al.*, 2014 and Satyal *et al.*, 2017) effects.

Deep Fat Frying (DFF) is a major cooking method and is considered to be one of the oldest methods of food preparation. During frying, there are many chemical reactions take place such as browning, gelatinization and denaturation due to the elevated temperature of the product. The process has a preserving action caused by thermal destruction of microorganisms, enzymes and reduction of water activity on the surface of the food (El-Lahamy *et al.* 2018). Therefore, the objective of this study was to evaluate the proximate composition, chemical, physical, and sensory properties of uncooked and semi-fried coated tilapia fillets which were manufactured by using two spices powder mixtures i.e., garlic and cumin (GC) and garlic and parsley (GP) as well as their volatile oils mixtures during frozen storage at -18°C for 3 months.

## **2. Materials and methods**

### **2.1. Materials**

#### **2.1.1. Fish**

Fresh Nile tilapia (*Oreochromis niloticus*) fish were obtained from local market at Giza governorate, Egypt. Fish were transferred to the laboratory in an ice box within 30 min then fish fillets were prepared immediately as shown in technological methods.

#### **2.1.2. Spices and their volatile oils**

Three different spices (garlic powder, parsley powder and cumin powder, sieve size 60 mesh) and their volatile oils were obtained from Kato Flavors & Fragrance Company at Shooting Club Street, Mohandessn, Giza, Egypt.

#### **2.1.3. Ingredients used in preparation of edible coating**

Corn flour, fresh egg, skimmed milk, salt and bread crumb were obtained from the local market at Giza, Egypt.

#### **2.1.4. Sunflower seed oil**

Refined sunflower seed oil produced by Misr Gulf Oil Processing CO. (MIGOP), Suez, Egypt and it was obtained from the local market at Giza, Egypt.

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### **2.2. Methods**

#### **2.2.1. Technological methods**

##### **2.2.1.1. Preparation of tilapia fish fillets**

The tilapia fishes were washed with water, beheaded, gutted skinned and washed. The skinned tilapia fish were filleted manually in iced condition. The fillets were divided into uniformly sized pieces (thickness ~ 1.5 cm, width ~ 6 cm and length ~ 10 cm) of ~100 g.

##### **2.2.1.2. Preparation of edible coating**

Edible coating was prepared by mixing the following mixture (94% corn flour and 2% egg yolk and 2% skimmed milk, 1.8 % salt and 0.2 % cumin) with water by 1:3 (w:v), respectively in homogenizer (Edmund Bühler, Tühler,Tübingen, Typ. Hov Nr. 52) for 5 min to obtain coating mixture (**Osheba et al., 2013**).

##### **2.2.1.3. Preparation of uncooked and semi-fried coated tilapia fillets:**

Five batches of coated tilapia fillets were manufactured in this study (Figure 1). The first batch (as a control sample) was coated by immersing tilapia fillets in edible coating. Other batches were coated by immersing tilapia fillets in edible coating contained 2.0% powder mixture of 1.0% garlic and 1.0% cumin (GC), 2.0% powder mixture of 1.0% garlic and 1.0% parsley (GP), 500 ppm volatile oils mixture of GC (250 ppm garlic and 250 ppm cumin) and 500 ppm volatile oils mixture of GP (250 ppm garlic and 250 ppm parsley) for 2 minutes at room temperature, then laid on racks for 30 sec to remove the excess solution and were covered with bread crumb. The abovementioned batches were divided into two groups. The first group of different coated tilapia fillets was served as raw (uncooked). On the hand, the second group was semi-fried in sunflower seed oil at  $180 \pm 5^\circ\text{C}$  for 3 minutes, the excess oil was removed by placing the coated tilapia fillets in filter paper and then allowed to cool at room temperature. The uncooked and semi-fried coated tilapia fillets were packaged in a foam plate, wrapped with polyethylene film and stored at  $-18^\circ\text{C}$  for three months. Samples were taken for analysis every month periodically.

#### **2.2.2. Analytical methods**

##### **2.2.2. 1. Proximate composition**

The contents of moisture, crude protein, crude fat and total ash of raw and coated fish fillets samples were determined according to the methods described by **A.O.A.C. (2012)**. The moisture content was determined by drying the minced samples in an oven at  $105^\circ\text{C}$  until a constant weight. The crude protein content was determined by the Microkjeldahl method and using the conversion factor  $6.25 \times N$ . The crude fat content was determined using Soxhlet apparatus. Fat was calculated by weight loss after cycle extractions with petroleum ether in Soxhlet apparatus. The ash content was determined using a muffle-furnace at  $550^\circ\text{C}$  for 6 hrs. Meanwhile the content of total carbohydrates was calculated by difference as follows:

Total carbohydrate =  $100 - \% (\text{moisture} + \text{crude protein} + \text{crude fat} + \text{total ash})$ .

##### **2.2.2.2. Determination of total volatile base nitrogen (TVB-N) and trimethylamine nitrogen (TMA-N)**

Total volatile base nitrogen (TVB-N) and Trimethylamine Nitrogen (TMA-N) were estimated by the semi-microdistillation procedure (Winton and Winton, 1958) as follow: Four hundred ml of filtrate (from 50g of minced chicken meat soaked in 1000 ml distilled water over night) were measured into each of two filtrate distillation flasks, then 30 ml of ethanol and 2g of magnesium oxide were added to each flask, attached each to an inclined condenser and distill into a 1 liter Erlenmeyer flask containing 25 ml of 0.1 N sulfuric acid. The distillation was continued until about three fourth of liquid has passed and the exact stopping point was determined by testing with litmus paper. Both distillates were boiled until the carbon dioxide has been removed. (10 to 15 minutes). After the cooling to room temperature, 0.2 ml of 0.2% resolic acid indicator was added to each flask and the excess of sulphuric acid was

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titrated with 0.1 N NaOH (alkali). The milligrams of total volatile nitrogen per 100g of sample were obtained by multiplying the number of milliliters of bound acid by 7.0. Trimethylamine Nitrogen (TMA-N) was determined using the above mentioned TVB-N method after appropriate modification: formaldehyde was used to block the primary and secondary amines.

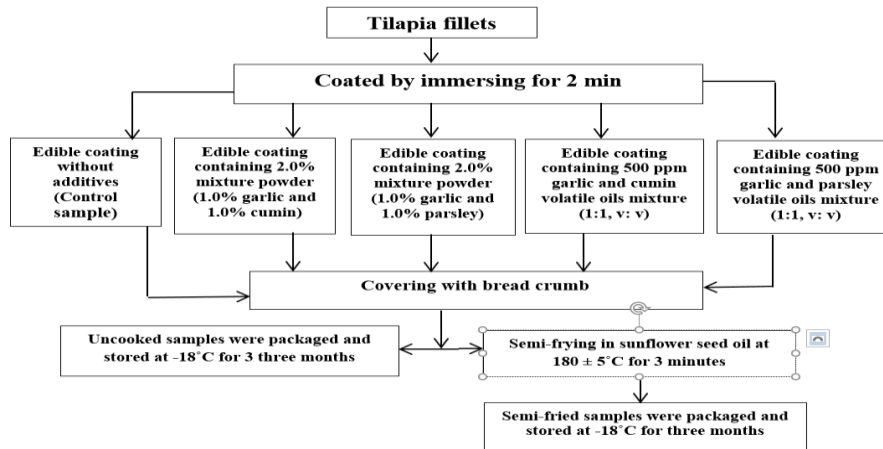


Figure (1): preparation of uncooked and semi-fried coated tilapia fillets.

#### 2.2.2.3. Determination of thiobarbituric acid (TBA)

The TBA of coated tilapia fillets was determined according to the method described by Kirk and Sawyer (1991). Ten grams of fatty food were macerated with 50ml water for 2 min and washed into distillation flask with 47.5ml water then 2.5 ml of 4M hydrochloric acid was added to bring the pH to 1.5. followed by an antifoaming preparation and a few glass beads. The flask was heated by means of an electric mantle so that 50 ml distillate was collected in 10 min from the time of boiling commences. Five ml of distillate was pipetted into a glass-stopper tube, 5 ml T.B.A reagent (0.2883 g/100 ml of 90 percent glacial acetic acid) was added, stoppered, Shaked and heated in boiling water for 35 min. Simultaneously, a blank was prepared using 5 ml distilled water with 5 ml reagent, then the tubes were cooled in water for 10 min and measure by spectrophotometer, the absorbance (D) against the blank at 538 nm using 1 cm cells.

$$\text{TBA No} = (\text{as mg malonaldehyde per kg sample}) = 7.8 D$$

#### 2.2.2.4. Determination of pH value

The pH values of different coated fillets fish were measured by homogenizing 10 g of the sample with 100 ml distilled water for 30 sec. The pH of the prepared sample was measured using a pH-meter (Jenway 3510 pH meter) at 20°C according to the method described by Fernández-López *et al.* (2006).

#### 2.2.2.5. Water holding capacity and plasticity

Water holding capacity and plasticity of coated tilapia fillets were measured using the method of Soloviev (1966). Minced sample (0.3 g) was placed on filter paper Whatman No. 41, between two glass plates and pressed for 10 minutes using one Kg weight. Two zones were formed on the filter paper (The outer zone resulted from the water separated from the pressed tissues and the internal zone was formed due to the sample pressed) and their surface areas were measured by a planimeter. The Water holding capacity (WHC) was calculated by the difference between the two areas, while plasticity was expressed as the internal area zone. Data were presented as cm<sup>2</sup>.

#### 2.2.2.6. Cooking loss:

Cooking losses of raw and semi-fried coated tilapia fillets were determined and calculated as described by A.M.S.A (1995). This measurement was carried out after the frying in sunflower oil at 140°C for 3 and 6 minutes for semi-fried and raw coated tilapia fillets, respectively. The frying losses were calculated as follows:

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% Cooking loss = (Raw or semi-fried fillets weight – fried fillets sample weight) / (Raw or semi-fried tilapia fillets sample weight) × 100

### 2.2.2.7. Sensory evaluation:

Sensory quality attributes of coated tilapia fillets were carried out according to Ojagh *et al.* (2013). Sensory evaluation was carried out at zero time and during frozen storage at -18°C up to 3 months. The uncooked tilapia fillets and semi fried fillets were deep-fried in sunflower oil at 180° C for 6 and 3 minutes, respectively and left to cool at room temperature for 5 min. The fried tilapia fillets samples were evaluated by a panel composed of ten staff members from Meat and Fish Technology Research Department of the Food Technology Research Institute, Giza, Egypt. Randomly coded samples were served to panelists individually. Five sensory attributes were evaluated (taste, odor, color, texture, and overall acceptability) using ten points hedonic scale for each trait where 9-10 = like extremely, 7-8 = like very much, 6 = like moderately, 5 = neither like nor dislike, 4 = dislike moderately, 3 = dislike very much and 1-2 = dislike extremely.

### 2.2.2.8. Statistical analysis:

Data are presented as mean ± SD (standard deviations). A completely randomized 3 (additive type) × 2 (additive form) × 2 (cooking process) × 4 (storage period) × 3 (replication) factorial designs was used for coated tilapia fillets. An analysis of variance was conducted using Costat version 6.311 (Copyright 1998-2005, CoHort software). When a significant main effect was detected, the means were separated with the Student Newman Keuls test. The predetermined acceptable level of probability was 5% ( $P \leq 0.05$ ) for all comparisons.

## 3. Results and discussion

### 3.1. Proximate composition of fresh tilapia fillets

Data presented in Table (1) showed the proximate composition of fresh tilapia fillets. From these results, it could be observed that fresh tilapia fillets contained 77.94% moisture, 18.62% crude protein, 1.86% crude fat, 1.39% total ash and 0.19% carbohydrates content (on a wet weight basis). Meanwhile, these values reached 84.41% crude protein, 8.43% crude fat, 6.30% total ash and 0.86% carbohydrates content (On dry weight basis). These results are in agreement with those obtained by Ali *et al.* (2019) found that minced tilapia fish contained 78.26% moisture, 18.59% protein, 1.97% lipid and 1.18% total ash. Also, Mohamed *et al.* (2019) reported that chemical composition of tilapia fish from Al-Batts drain farm and El-Wadi drain farm were 79.41 and 79.38% moisture, 18.05 and 17.89% protein, 1.12 and 1.23% lipid and 1.14 and 1.21% ash, respectively.

**Table (1): Proximate composition of fresh tilapia fillets**

Chemical composition (%)	Fresh tilapia fillets	
	WW	DW
Moisture content	77.94	-
Crude protein	18.62	84.41
Crude fat	1.86	8.43
Total ash	1.39	6.30
Carbohydrates	0.19	0.86

WW: wet weight basis. DW: dry weight basis.

### 3.2. Proximate composition of coated tilapia fillets

According to statistical analysis of data in Table (2) it could be noticed that proximate composition of coated tilapia fillets was not affected ( $p > 0.05$ ) by the type and form of additives. There were no significant differences ( $p > 0.05$ ) in all chemical compositions between coated tilapia fillets without additives and fillets coated with different

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types of additives (GP and GC), also between coated tilapia fillets prepared with volatile oils mixtures and coated tilapia fillets prepared with spices powder mixtures. These results are in agreement with Abd El-Qader (2004) reported that no significant differences in all chemical composition between burger prepared with volatile oils mixture and burger prepared with spices mixture.

Proximate composition of coated tilapia fillets was significantly affected ( $p \leq 0.05$ ) by cooking process. Semi-fried coated tilapia fillets had significantly lower ( $p \leq 0.05$ ) moisture content (63.30%) but significantly higher crude protein (18.45%), crude fat (5.97%), total ash (1.94%) and carbohydrates content (10.53%) than uncooked coated tilapia fillets. Semi frying process significantly reduced ( $p \leq 0.05$ ) moisture content by 9.09%. This reduction in moisture content may be attributed to the releasing water which was not bound tightly by proteins during cooking process. On the other hand, the increment of crude protein, crude fat, total ash and carbohydrates contents were attributed to the reduction of moisture content during semi frying process. Also, the increment of fat content in semi fried tilapia fillets might be related to the coated layer components that impeded the lipid loss and led to the oil absorption from the frying oil medium (Raeisi *et al.* 2016). Similar results were obtained by Mohamed *et al.* (2019) reported that moisture of raw Nile tilapia fish decreased by deep frying from 79.38% to 68.09%, meanwhile protein, lipid and ash contents increased from 17.89, 1.23 and 1.22 % to 24.69, 5.57 and 1.52%, respectively.

Also, proximate composition of coated tilapia fillets was significantly affected ( $p \leq 0.05$ ) by frozen storage periods at  $-18 \pm 1^\circ\text{C}$  for 3 months. Moisture and protein contents of coated tilapia fillets were significantly ( $p \leq 0.05$ ) decreased by increasing frozen storage periods. The loss of moisture could be attributed to the sublimation of ice in frozen storage and the loss of drip during thawing process (Ibrahim and El-Sherif, 2008 and El-Lahamy *et al.*, 2019a). The decrease in protein content during the storage might be due to slight loss of nitrogen (as volatile nitrogen) as a result of slight protein breakdown. These results are in accordance with those obtained by Mohamed *et al.* (2019) and El-Lahamy *et al.* (2019a) reported that moisture and protein contents of Nile tilapia Fish and mullet fish steaks decreased ( $P \leq 0.05$ ) by increasing frozen storage time. On the other hand, crude fat, total ash and carbohydrates contents of coated tilapia fillets were significantly ( $p \leq 0.05$ ) increased by increasing frozen storage periods. These increments might be attributed to the reduction of moisture and protein contents during frozen storage periods. These findings are on line with those obtained by El-Lahamy *et al.* (2019b) reported that ash and carbohydrate contents of sand smelt fish burger and fingers samples increased during frozen storage.

**Table (2). Proximate composition of coated tilapia fillets as affected by type and form of additives, cooking process during frozen storage at  $-18 \pm 1^\circ\text{C}$  up to 3 months**

Items	Moisture (%)	Crude protein (%)	Crude fat (%)	Total ash (%)	Carbohydrates (%)
<u>Type of additives</u>					
Without additives	66.35 <sup>a</sup> ±0.52	17.86 <sup>a</sup> ±0.42	4.01 <sup>a</sup> ±0.25	1.79 <sup>a</sup> ±0.08	9.99 <sup>a</sup> ±0.32
GP	66.25 <sup>a</sup> ±0.49	17.75 <sup>a</sup> ±0.43	3.98 <sup>a</sup> ±0.23	1.80 <sup>a</sup> ±0.12	10.22 <sup>a</sup> ±0.31
GC	66.26 <sup>a</sup> ±0.52	17.85 <sup>a</sup> ±0.38	3.96 <sup>a</sup> ±0.24	1.81 <sup>a</sup> ±0.09	10.12 <sup>a</sup> ±0.30
LSD at 0.05%	0.379	0.343	0.216	0.160	0.295
<u>Form of additives</u>					
Powder	66.21 <sup>a</sup> ±0.50	17.80 <sup>a</sup> ±0.41	3.92 <sup>a</sup> ±0.24	1.83 <sup>a</sup> ±0.09	10.25 <sup>a</sup> ±0.30
Volatile oil	66.30 <sup>a</sup> ±0.51	17.79 <sup>a</sup> ±0.39	4.02 <sup>a</sup> ±0.22	1.78 <sup>a</sup> ±0.07	10.10 <sup>a</sup> ±0.29
LSD at 0.05%	0.346	0.285	0.231	0.147	0.233
<u>Cooking process</u>					
Uncooked	69.43 <sup>a</sup> ±0.50	17.17 <sup>b</sup> ±0.40	1.99 <sup>b</sup> ±0.21	1.67 <sup>b</sup> ±0.09	9.74 <sup>b</sup> ±0.30
Semi-fried	63.12 <sup>b</sup> ±0.45	18.45 <sup>a</sup> ±0.35	5.97 <sup>a</sup> ±0.19	1.94 <sup>a</sup> ±0.06	10.53 <sup>a</sup> ±0.26
LSD at 0.05%	0.436	0.358	0.249	0.186	0.255
<u>Storage periods (month)</u>					
0	66.85 <sup>a</sup> ±0.51	18.04 <sup>a</sup> ±0.43	3.67 <sup>d</sup> ±0.22	1.52 <sup>c</sup> ±0.10	9.93 <sup>c</sup> ±0.32
1	66.53 <sup>b</sup> ±0.52	17.89 <sup>a</sup> ±0.45	3.88 <sup>c</sup> ±0.19	1.63 <sup>c</sup> ±0.07	10.08 <sup>b</sup> ±0.31
2	66.07 <sup>c</sup> ±0.49	17.81 <sup>a</sup> ±0.40	4.06 <sup>b</sup> ±0.20	1.91 <sup>b</sup> ±0.08	10.15 <sup>b</sup> ±0.29
3	65.65 <sup>d</sup> ±0.50	17.50 <sup>b</sup> ±0.39	4.31 <sup>a</sup> ±0.17	2.15 <sup>a</sup> ±0.10	10.39 <sup>a</sup> ±0.28
LSD at 0.05%	0.273	0.265	0.172	0.176	0.140

Data are presented as means  $\pm$  SD (standard deviation).

Means in the same column with different letters are significantly different ( $p \leq 0.05$ ).

GP: Mixture of garlic and parsley, GC: Mixture of garlic and cumin. means  $\pm$  SD (standard deviation).

**3.3. Chemical quality attributes of coated tilapia**

Total volatile nitrogen (TVN), trimethylamine (TMA) and thiobarbituric acid (TBA) of coated tilapia fillets were significantly affected ( $p \leq 0.05$ ) by the type and form of additives, cooking process and frozen storage at  $-18^{\circ}\text{C}$  up to 3 months as shown in Table (3). Coated tilapia fillets without additives had significantly higher ( $p \leq 0.05$ ) TVN (13.62 mg/100g), TMA (5.76 mg/100g), and TBA (0.848 mg malonaldehyde/kg) values than other tilapia fillets coated with different types of additives (GP and GC). This might be due to different types of additives (garlic, cumin and parsley) had antimicrobial activity which led to inhibit some microorganisms such as proteolytic bacteria which breakdown protein and psychrotrophic bacteria produce lipases which cause hydrolysis of fats as well as increase the level of free fatty acids (Davies and Board, 1998). Beside the antioxidant activity of these additives led to delay lipid oxidation. Similar results were obtained by Kuzgun *et al.* (2019) reported that trout fillets treated with garlic essential oil had lower TVBN and TBA values than untreated fillets. Also, coated tilapia fillets prepared with GC had significantly lower ( $p \leq 0.05$ ) TVN (10.53 mg/100g), TMA (5.01 mg/100g), and insignificantly lower ( $p > 0.05$ ) TBA (0.613 mg malonaldehyde/kg) values than coated tilapia fillets prepared with GP. This might be due to garlic and cumin mixture (GC) had higher antimicrobial and antioxidant activities than mixture of garlic and parsley mixture (GP).

**Table (3): Chemical properties of coated tilapia fillets as affected by type and form of activities and cooking process during frozen storage periods at  $-18 \pm 1^{\circ}\text{C}$  for 3 months.**

Items	TVN (mg/100g)	TMA (mg/100g)	TBA (mg malonaldehyde/kg)
<u>Type of additives</u>			
Without additives	13.62 <sup>a</sup> ±0.38	5.76 <sup>a</sup> ±0.25	0.848 <sup>a</sup> ±0.05
GP	11.20 <sup>b</sup> ±0.35	5.26 <sup>b</sup> ±0.22	0.686 <sup>b</sup> ±0.02
GC	10.53 <sup>c</sup> ±0.34	5.01 <sup>c</sup> ±0.20	0.613 <sup>b</sup> ±0.03
LSD at 0.05%	0.228	0.142	0.082
<u>Form of additives</u>			
Powder	11.44 <sup>a</sup> ±0.36	5.34 <sup>a</sup> ±0.20	0.677 <sup>a</sup> ±0.04
Volatile oil	10.29 <sup>b</sup> ±0.35	4.93 <sup>b</sup> ±0.24	0.622 <sup>a</sup> ±0.03
LSD at 0.05%	0.239	0.164	0.068
<u>Cooking process</u>			
Uncooked	11.97 <sup>a</sup> ±0.39	5.55 <sup>a</sup> ±0.22	0.600 <sup>b</sup> ±0.02
Semi-fried	10.85 <sup>b</sup> ±0.36	4.97 <sup>b</sup> ±0.20	0.778 <sup>a</sup> ±0.03
LSD at 0.05%	0.375	0.138	0.066
<u>Storage periods (month)</u>			
0	8.28 <sup>d</sup> ±0.38	2.83 <sup>d</sup> ±0.26	0.458 <sup>d</sup> ±0.04
1	9.85 <sup>c</sup> ±0.34	4.56 <sup>c</sup> ±0.24	0.561 <sup>c</sup> ±0.03
2	12.34 <sup>b</sup> ±0.45	6.06 <sup>b</sup> ±0.22	0.755 <sup>b</sup> ±0.04
3	15.19 <sup>a</sup> ±0.33	7.60 <sup>a</sup> ±0.24	0.983 <sup>a</sup> ±0.02
LSD at 0.05%	0.254	0.199	0.091

Data are presented as means ± SD (standard deviation).

Means in the same column with different letters are significantly different ( $p \leq 0.05$ ).

GP: Mixture of garlic and parsley, GC: Mixture of garlic and cumin

Coated tilapia fillets with coating contained volatile oils mixtures had significantly lower ( $p \leq 0.05$ ) TVN (10.29 mg/100g), TMA (4.93 mg/100g) and insignificantly lower ( $p > 0.05$ ) TBA (0.622 mg malonaldehyde/kg) values than coated tilapia fillets with coating contained spices powder. This might be due to volatile oils had strong antimicrobial and antioxidant activities than spices powder. These results in agreement with Abd El-Qader (2004) found that burger prepared with volatile oils mixture had lower TVN and TBA values than burger prepared with the same spices mixture powder.

Semi-fried coated tilapia fillets had significantly lower ( $p \leq 0.05$ ) TVN (10.85 mg/100g) and TMA (4.97 mg/100g) but significantly higher TBA value (0.778 mg malonaldehyde /kg) than uncooked coated tilapia fillets. Semi

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frying process reduced ( $p \leq 0.05$ ) TVN and TMA values by 9.36 and 10.45% respectively. This reduction could be attributed to volatilize the volatile compounds such as ammonia trimethylamine and dimethylamine during cooking process (Ali *et al.*, 2019). These results are in agreement with those obtained by El-Lahamy *et al.* (2018) found that TVB-N of raw mullet fish (13.25 mg/100g) was decreased by frying to 12.48 mg/100g. The increment of TBA values for semi-fried tilapia fillets might be due to oxidation of sunflower seed oil during semi-frying process (Hamza, 2011). Similar results were obtained by Ali *et al.* (2019) for fish burger.

The TVN, TMA and TBA values of coated tilapia fillets were significantly ( $p \leq 0.05$ ) increased by increasing frozen storage period. The increment of TVN and TMA during frozen storage could be attributed to the bacterial breakdown associated with the formation of some alkaline substances such as ammonia and confirmed the rapid development in total volatile nitrogen. Similar results were obtained by Osheba *et al.* (2013) for fish finger. However, the increment of TBA values during the frozen storage could be attributed to ice crystals formed could injure the cell and cause the release of pro-oxidation, especially free iron (Osman and Zidan, 2014). These results are in agreements with those obtained by Saleem *et al.* (2019) who mentioned that TBA values of all fish burger and finger samples increased as the storage period increased.

Physical properties of coated tilapia fillets:

From statistical analysis in Table (4) it could be noticed that, there were no significant differences ( $p > 0.05$ ) in plasticity values between coated tilapia fillets prepared without additives and coated tilapia fillets with different additives (GP and GC). On the contrary, coated tilapia fillets prepared without additives had significantly higher ( $p \leq 0.05$ ) pH value (6.40), water holding capacity value (worst WHC 2.87cm<sup>2</sup>/g) and cooking loss (21.95%) than coated tilapia fillets with GC and GP. Meanwhile, no significant differences ( $p > 0.05$ ) were observed in abovementioned parameters between tilapia fillets coated with GP and fillets coated with GC. The lower pH value in coated tilapia fillets with different additives may be due to the effectiveness of these additives as an antimicrobial agent against some microorganisms such as proteolytic bacteria which hydrolysis fish protein to simple proteins, polypeptides, amino acids, ammonia and trimethylamine and other volatile bases. These results are on line with those obtained by El-Sherif *et al.* (2011) reported that pH values were significantly higher in control samples of catfish burgers and fingers than samples treated by EOs. The best water holding capacity and cooking loss of coated tilapia fillets with different types of additives (GP and GC) might be due to antioxidant activity of these additives which retard the lipid oxidation and hydrolysis end products which combined with protein and made it insoluble which caused the reduction of water holding capacity (Varnam and Satheland, 1995).

Also, from the same table, it could be noticed that all physical properties of coated tilapia fillets were not affected ( $p > 0.05$ ) by the form of additives (powder or volatile oils), but significantly affected ( $p \leq 0.05$ ) by cooking process. Semi fired coated tilapia fillets had significantly higher ( $p \leq 0.05$ ) pH value (6.124) than uncooked coated tilapia fillets. This might be the formation of some basic compounds as a result of amino acid degradation (Hafez, 1982).

Uncooked coated tilapia fillets had significantly higher ( $p \leq 0.05$ ) water holding capacity value (lowest or worst WHC, 2.88 cm<sup>2</sup>/g), plasticity (2.32cm<sup>2</sup>/g) and cooking loss (22.39%) than semi-fried coated tilapia fillets. The best water holding capacity of semi-fried coated tilapia fillets was also recorded by El- Kordy (2006) for semi fish patties and Hamza (2011) for semi-fried chicken finger. On the other hand, the reduction of plasticity by semi-frying process might be explained by the effect of heat treatment on the muscle protein denaturation. Similar results were obtained by El- Kordy (2006) who found that the plasticity was also decreased by semi-frying process of fish patties. Physical properties of coated tilapia fillets were significantly affected ( $p \leq 0.05$ ) by frozen storage periods at  $-18 \pm 1^\circ\text{C}$ . The pH values and cooking loss of coated tilapia fillets were significantly ( $p \leq 0.05$ ) increased by increasing frozen storage period. The increase pH value might be due to the accumulation of alkaline compounds such as ammonium compounds and TMA, mainly derived from microbial action (Bensid *et al.*, 2014). The increment of cooking loss might be due to protein denaturation and the loss of protein solubility which led to decrease the water holding capacity (Abd El-Qader, 2014). Similar results were obtained by El-Kordy (2006) reported that cooking loss of fish patties was increased by storage time increased.

**Table (4): Physical properties of coated tilapia fillets as affected by type and form of additives and cooking process during frozen storage at -18±1°C up to 3 months.**

Items	pH value	WHC (cm <sup>2</sup> /0.3g)	Plasticity (cm <sup>2</sup> /0.3g)	Cooking loss (%)
<u>Type of additives</u>				
Without additives	6.40 <sup>a</sup> ±0.25	2.87 <sup>a</sup> ±0.17	1.94 <sup>a</sup> ±0.10	21.95 <sup>a</sup> ±0.45
GP	6.22 <sup>b</sup> ±0.20	2.56 <sup>b</sup> ±0.16	1.97 <sup>a</sup> ±0.12	20.49 <sup>b</sup> ±0.50
GC	6.14 <sup>b</sup> ±0.23	2.51 <sup>b</sup> ±0.15	1.96 <sup>a</sup> ±0.11	20.49 <sup>b</sup> ±0.47
LSD at 0.05%	0.162	0.278	0.262	0.243
<u>Form of additives</u>				
Powder	6.234 <sup>a</sup> ±0.24	2.53 <sup>a</sup> ±0.18	1.94 <sup>a</sup> ±0.11	20.54 <sup>a</sup> ±0.50
Volatile oil	6.124 <sup>a</sup> ±0.25	2.54 <sup>a</sup> ±0.15	1.99 <sup>a</sup> ±0.13	20.44 <sup>a</sup> ±0.45
LSD at 0.05%	0.143	0.213	0.281	0.250
<u>Cooking process</u>				
Uncooked	6.104 <sup>b</sup> ±0.23	2.88 <sup>a</sup> ±0.16	2.32 <sup>a</sup> ±0.12	22.39 <sup>a</sup> ±0.52
Semi-fried	6.342 <sup>a</sup> ±0.24	2.32 <sup>b</sup> ±0.14	1.61 <sup>b</sup> ±0.10	19.17 <sup>b</sup> ±0.48
LSD at 0.05%	0.212	0.341	0.355	0.367
<u>Storage periods (month)</u>				
0	5.967 <sup>c</sup> ±0.26	2.37 <sup>c</sup> ±0.15	2.20 <sup>a</sup> ±0.12	18.95 <sup>d</sup> ±0.51
1	6.176 <sup>b</sup> ±0.24	2.49 <sup>bc</sup> ±0.14	2.05 <sup>b</sup> ±0.12	20.19 <sup>c</sup> ±0.48
2	6.322 <sup>ab</sup> ±0.25	2.70 <sup>a</sup> ±0.16	1.89 <sup>c</sup> ±0.13	21.43 <sup>b</sup> ±0.45
3	6.428 <sup>a</sup> ±0.23	2.86 <sup>a</sup> ±0.18	1.71 <sup>d</sup> ±0.14	22.56 <sup>a</sup> ±0.46
LSD at 0.05%	0.184	0.163	0.142	0.271

Data are presented as means ± SD (standard deviation).

Means in the same column with different letters are significantly different (p≤0.05).

GP: Mixture of garlic and parsley, GC: Mixture of garlic and cumin

Furthermore, during frozen storage at -18±1°C, the water holding capacity (i.e., separated free water increased) and plasticity were significantly decreased with advancement of storage time. This reduction may be attributed to protein denaturation and loss of protein solubility. In this concern, **Abd EL-Qader (2014)** who reported that as the protein denaturants, its ability to bind water decreases. These findings are in agreement with the results of **El-Kordy (2006)** found that water holding capacity and plasticity of raw and semi fried fish patties were decreased by increasing storage period.

### 3.4. Sensory properties of coated tilapia fillets

From statistical analysis of data in Table (5) it could be noticed that all sensory properties of coated tilapia fillets were significantly affected (p ≤ 0.05) by the type and form of additives, cooking process and frozen storage at -18°C for 3 months. There were significant differences (p ≤ 0.05) in all sensory properties scores between coated tilapia fillets without additives (control sample) and tilapia fillets coated with different types of additives (GP and GC), except texture score. Also, non-significant differences (p ≤ 0.05) in all sensory properties scores were observed between coated tilapia fillets prepared with GP and GC. Coated tilapia fillets without additives had significantly lower scores of taste (7.53), odor (6.64), color (6.75), texture (7.15) and overall acceptability (7.02) than that coated with different additives (GC and GP). In this concern, **Ozpolat and Duman (2017)** reported that fish fillets treated with black cumin were highly preferred by panelists than control sample.

Coated tilapia fillets prepared with volatile oils mixtures had significantly higher (p ≤ 0.05) scores of taste, odor, color, texture and overall than coated tilapia fillets prepared with spices mixtures powder. The sensory properties of coated tilapia fillets prepared with volatile oils had rating described as like very much (7.48 -8.22). However, coated tilapia fillets prepared with spices mixtures powder had rating described as like moderately (6.85) and like very much (7.14 -7.64). This might be due to spices volatile oils had strong antimicrobial and antioxidant

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activities than spices powder which led to improve sensory properties of coated tilapia fillets by reduce deterioration of them which caused by oxidation and microbial growth (Abd El-Qader, 2014).

Also, semi-fried coated tilapia fillets had significantly lower ( $p < 0.05$ ) scores of taste (7.52), odor (7.19), color (6.72) and overall acceptability (7.26) but significantly higher texture (7.63) than uncooked coated tilapia fillets. The sensory properties of uncooked and semi fried coated tilapia fillets had rating described as like moderately to like very much. Similar results were obtained by El-Kordy (2006) who reported that semi-fried fish patties had lower sensory properties than uncooked fish patties.

Sensory properties of coated tilapia fillets were significantly affected ( $p \leq 0.05$ ) by frozen storage periods at  $-18 \pm 1^\circ\text{C}$ . The taste, odor, color, texture and overall acceptability scores of coated tilapia fillets were significantly ( $p \leq 0.05$ ) decreased by increasing the storage period. At the end of storage period, sensory properties of coated tilapia fillets had rating scores described as like moderately (6.03 – 6.90). The decrement of sensory properties during frozen storage could be attributed to oxidation potential of fatty acids present in tilapia fillets resulted in generation of secondary products of fatty acid auto-oxidation such as aldehydes, ketones, hydrocarbons, esters, furans and lactans. These products are probably responsible for flavor deterioration during storage (Hyldig *et al.*, 2012).

**Table (5): Sensory properties of coated tilapia fillets as affected by type and form of additives and cooking process during frozen storage at  $-18 \pm 1^\circ\text{C}$  up to 3 months.**

Items	Taste	Odor	Color	Texture	Overall
<b>Type of additives</b>					
Without additives	7.53 <sup>b</sup> ±0.62	6.64 <sup>b</sup> ±0.54	6.75 <sup>b</sup> ±0.23	7.15 <sup>a</sup> ±0.34	7.02 <sup>b</sup> ±0.42
GP	7.81 <sup>a</sup> ±0.60	7.68 <sup>a</sup> ±0.58	7.24 <sup>a</sup> ±0.30	7.07 <sup>a</sup> ±0.35	7.45 <sup>a</sup> ±0.46
GC	8.04 <sup>a</sup> ±0.58	7.45 <sup>a</sup> ±0.52	7.46 <sup>a</sup> ±0.33	7.27 <sup>a</sup> ±0.40	7.55 <sup>a</sup> ±0.45
LSD at 0.05%	0.271	0.243	0.262	0.224	0.254
<b>Form of additives</b>					
powder	7.64 <sup>b</sup> ±0.63	7.39 <sup>b</sup> ±0.59	7.14 <sup>b</sup> ±0.32	6.85 <sup>b</sup> ±0.40	7.25 <sup>b</sup> ±0.49
Volatile oil	8.22 <sup>a</sup> ±0.59	7.75 <sup>a</sup> ±0.50	7.57 <sup>a</sup> ±0.21	7.48 <sup>a</sup> ±0.35	7.75 <sup>a</sup> ±0.41
LSD at 0.05%	0.236	0.273	0.281	0.242	0.239
<b>Cooking process</b>					
Uncooked	8.17 <sup>a</sup> ±0.60	7.58 <sup>a</sup> ±0.55	7.74 <sup>a</sup> ±0.28	6.70 <sup>b</sup> ±0.41	7.55 <sup>a</sup> ±0.45
Semi-fried	7.52 <sup>b</sup> ±0.57	7.19 <sup>b</sup> ±0.50	6.72 <sup>b</sup> ±0.31	7.63 <sup>a</sup> ±0.38	7.26 <sup>b</sup> ±0.44
LSD at 0.05%	0.332	0.347	0.359	0.386	0.261
<b>Storage periods (months)</b>					
0	8.62 <sup>a</sup> ±0.58	8.58 <sup>a</sup> ±0.59	8.12 <sup>a</sup> ±0.29	7.83 <sup>a</sup> ±0.33	8.29 <sup>a</sup> ±0.45
1	8.10 <sup>b</sup> ±0.60	7.76 <sup>b</sup> ±0.55	7.68 <sup>b</sup> ±0.30	7.53 <sup>b</sup> ±0.35	7.76 <sup>b</sup> ±0.43
2	7.76 <sup>c</sup> ±0.57	7.16 <sup>c</sup> ±0.57	6.96 <sup>c</sup> ±0.32	7.04 <sup>c</sup> ±0.42	7.23 <sup>c</sup> ±0.47
3	6.90 <sup>d</sup> ±0.63	6.03 <sup>d</sup> ±0.58	6.17 <sup>d</sup> ±0.34	6.27 <sup>d</sup> ±0.40	6.34 <sup>d</sup> ±0.49
LSD at 0.05%	0.281	0.260	0.372	0.279	0.243

Data are presented as means  $\pm$  SD (standard deviation).

Means in the same column with different letters are significantly different ( $p \leq 0.05$ ).

GP: Mixture of garlic and parsley, GC: Mixture of garlic and cumin.

## 4. Conclusion

From the above results, it could be concluded that addition of garlic and cumin mixture (GC) in the form of powder or volatile oils was more effective for improving the quality attributes of coated tilapia fillets than garlic and parsley mixture (GP). Spices volatile oils mixtures (GC and GP) were more effective than spices powder mixtures for improving chemical and sensory properties of coated tilapia fillets during frozen storage at  $-18^\circ\text{C}$  for 3 months. Finally, it could be recommended to use the abovementioned spice powders and their volatile oil mixtures in the production of coated fish fillets commercially

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