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Effect of Three Cooking Techniques on Nile Tilapia (*Oreochromis niloticus*) Burgers Quality Attributes

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ABSTRACT

Three cooking techniques (pan frying in corn oil, roasting in a Halogen convection oven, and grilling in a double jacket electric grill) were evaluated for their effect on the quality attributes (cooking characteristics, chemical composition, fatty acids, amino acids, physicochemical properties, microbiological activity, sensory evaluation, and cost-profit analysis) of the Nile tilapia (*Oreochromis niloticus*) burgers. The Nile tilapia weighed an average of 500 grams and contained 52.13% edible flesh. There were no significant ($p \leq 0.05$) differences in the proximate chemical composition of roasted and grilled burgers. While, the frying technique and both other cooking techniques differs significantly ($p \leq 0.05$). In terms of pH, total volatile base nitrogen, and thiobarbituric acid reactive substances values, there were no significant differences ($p \leq 0.05$) between the three cooking techniques. During the frying process, the fatty acids and amino acids content of the fish burgers was considerably influenced. The results of the sensory evaluation of fish burgers revealed that fried and grilled burgers had better color, odor, appearance, and overall acceptability than roasted burgers. The Nile tilapia burgers were proven to be good for human eating, roasted and grilled as cooking methods for a healthy diet. The current research paves the way for optimal use of this product with profit margin 83.33%, especially during the peak of fishing season.

***Keywords*:** cooking methods; fish burger; Nile tilapia; proximate composition; quality attributes.

INTRODUCTION

In 2018, worldwide fish production was estimated to be 179 million tonnes (88% human consumption and 12% non-food purposes), with a global human consumption rate of 20.5 kg/capita. The fish for human consumption included 44% of fresh and/or chilled fish, 35% of frozen fish, 11% of preserved and manufactured fish, and 10% of cured fish. China is the world's largest fish producer, producing 62.2 million tonnes per year. In Africa, Egypt is the largest fish producer, producing around 1.9 million tonnes per year and expected to increase to approximately 2.6 million tonnes by 2030 (FAO, 2020). Egyptian aquaculture has a market value of about 2.18 $ billion, making it the largest market in Africa (CAPMAS, 2014).

For Nile tilapia, the world production is estimated to be 6.4 million tonnes per year. Egypt is the world's third largest producer of cultivated tilapia fish, after China (1.8 million tonnes) and Indonesia (1.1 million tonnes), with 900 thousand tons of Nile tilapia produced per year (USDA, 2020). Fish producers in Egypt have become interested in farming of tilapia since it is easy to cultivate and grows rapidly (Mur, 2014).

The fish chemical composition was essential to investigate because it influences post-harvest processing, shelf life, quality attributes, and technological characteristics. Proximate chemical profiles are frequently tested to ensure that fish meet commercial requirements and food regulations (Waterman, 2000). Fish proximate chemical composition is influenced by species, size, age, gender, diet, organs, tissue location, biological cycle, environment, and season (FAO/WHO, 2011). Fish flesh has a variety of components, including moisture, fats, protein, carbohydrate, minerals and vitamins, which together affect the total flesh proximate composition.

In general, fish have a low carbohydrate, high moisture contents, and so little in the type of minerals and vitamins (Oluwaniyi & Dosumu, 2009). Almost about 15 - 25 % protein, 60 - 80 % moisture, and 2 -14 % fats were found in the majority of fish species (Pearson, 1976). The dry matter of red or oily fish species can contain up to 29 % oil, while white fish have less oil (Gomma *et al*., 2020). Fish are highly enriched in all essential amino acids, which is rare in grains. Fish protein can act as a nutritional supplement to improve the amino acid supply in the diet (UNF& AO, 2005). Amino acids and fatty acids are found in large quantities in the muscle of fish. On the other hand, fish has low saturated fatty acid level and fat, making it a heart-healthy option. In this way, the patient has the option of obtaining excellent quality protein without consuming excessive amounts of fat. A healthy heart may be maintained by eating fish (Ackman, 1990).

Nile tilapia fish is the most important fish species consumed and cultivated in Egypt. The flesh quality of wild Nile tilapia fish differs from that of farmed fish. For example, farmed Nile tilapia has a higher moisture content than wild Nile tilapia fish. Nile tilapia flesh yielded 46.3 to 47.3 % of total body weight, while non-edible components ranged from 49.7 to 51.7 % of total body weight. On a dry matter basis, the chemical composition of Nile tilapia collected from four distinct geographical locations in Egypt ranged from 70.8 to 80.3% moisture, 53.6 to 58.1 % protein, and 21.7 to 23.5% lipid (El-Zaeem *et al*., 2012). However,

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on a wet basis, the moisture content of Nile tilapia ranged from 78.6 to 80.8 %, protein ranged from 16.1 to 17.9 %, fat ranged from 1.2 to 1.9 %), ash ranged from 0.6 to 1.5 %, carbohydrates ranged from 0.1 to 0.9 %, and calorific values ranged from 78.4 to 89.7 Cal /100g (Talab *et al*., 2016). In Nile tilapia, the fatty acid composition was 42.4 % monounsaturated fatty acids, 35.5 % saturated fatty acids, and 22.2 % polyunsaturated fatty acids. The main fatty acids were oleic, linoleic, linolenic, and palmitoleic acid. The amino acid profile included 37.6% total essential amino acids, 28.8% acidic amino acids, 3.9% sulfur amino acids, and 12.1% aromatic amino acids. Glutamic, aspartic, leucine, alanine, arginine, and lysine were the most abundant amino acids (Oluwaniyi *et al*., 2017).

Throughout the world, fish burgers are a top-selling culinary product. Fish products and/or fish are commonly served after they have been frozen and/or processed in some manner. Heated foods reduce the growth of harmful germs, enhance flavour, and prolong shelf life. In the manufacture and final preparation of precooked food products, oxidation is responsible for some of the most important alterations (Bongar, 1998).

In the literature, there are very lack of research studies on Nile tilapia fish products. According to Tokur *et al*., (2004), tilapia fish burgers were tested for sensory and chemical changes before consumption. A number of studies have been conducted on the stability and quality of fish burgers manufactured from Arabian sea meagre, catlal, and rainbow trout (Taskaya *et al.,* 2003; Al-Bulushi *et al*.., 2005; Vanitha *et al.,* 2015). Fish fillets were cooked in various methods to reduce moisture and enhance protein content of *Rhamdia quelen* (Weber *et al.,* 2008). This also applied to *Sardina pilchardus* fillets, which were affected by cooking methods (Garca-Arias et al., 2003). According to a study by Bochi *et al*., (2008), the water holding capacity and fat content of *Rhamdia quelen* burgers made from flesh and filleting wastes was equivalent after cooking. Moreover, the cooking process had an influence on the colour and brightness of *Rhamdia quelen* burgers.

The Nile tilapia (*Oreochromis niloticus*) was selected for this study due to its availability, low cost, and high customer acceptability. In spite of its low-fat content, this fish has a very high commercial value. Nutritional information, including how cooking method and processing may affect nutritional quality, is limited for these species. The nutritional value and chemical composition of marine fishes has been shown to be altered by cooking methods in previous studies (Oluwaniyi, *et al,* 2010).

To our knowledge, Nile tilapia burgers have not been investigated for their cooking characteristics and quality attributes in Egypt. So, in this study, Nile tilapia (*Oreochromis niloticus*) fish burgers were developed. Also, the research examined the impact of three common cooking techniques (grilling, roasting, and frying) on the cooking characteristics, quality attributes (chemical composition, physicochemical properties, fatty acids content, amino acids content, microbiological activity, and sensory evolution), and cost- profit assay of prepared tilapia fish burgers, considering the significance of expanding fish products lines due to their high nutritional properties, as well as the lack of studies in this area.

MATERIALS AND METHODS

Materials

Chemicals

All chemicals used in this study were of analytical grade and purchased from Sigma Aldrich, Cairo, Egypt.

Source of Nile-Tilapia (*Oreochromis niloticus*)

In this study, Nile tilapia (*Oreochromis niloticus*) was selected due to its local availability in the Egyptian market at affordable prices to consumers. Fish were purchased from the fishermen at the local fish market in Damietta, Egypt during October 2018 to March 2019. Immediately after fish purchasing, it was transported into an isothermal icebox (Brand: Orocan, 15 kg capacity) at 3 ± 1ºC and transported to the laboratory of Food Industries Department, Faculty of Agriculture, Damietta University, Egypt. The average size of the Nile tilapia was 500 gm and average length 37.50cm (Fig 1).

Fig .1. The selected Nile tilapia (*Oreochromis niloticus*) fish for this study.

Spices and Additives

Spices, onion powder, garlic powder, sugar, salt, and other additives were obtained from Damietta local market.

Microbial Strains and Cultivation Media

All microbial strains and cultivation media were obtained from the Departments of Plant Pathology and Microbiology, Faculty of Agriculture, Alexandria University, Egypt.

Nutrient agar (NA) medium was used for isolation, cultivation and maintenance of a wide variety of microorganisms from examined fish. To isolate and differentiate pathogenic enteric bacilli (*Salmonella spp. and Shigella spp*), Salmonella Shigella agar (SS agar) medium was used. Coliform bacteria were counted using MacConkey broth medium. *Staphylococci aureus* were isolated and counted using Staph-110 media (Atlas, 2010). Molds and yeasts were counted using Dicloran Glycerol 18 (DG-18). For the counting of *Clostridium botulinum* bacteria, the AOAC recommended using cooked beef broth medium (AOAC, 2016).

Methods

Weight and Length Assay of Nile Tilapia

The fish weight assay calculates the weight of each part and organ of the fish as a percentage of the total weight. On the other hand, the fish length assay estimates the length of each part (head, trunk, and tail) of the fish as a percentage of its overall length. It is important to know the weight and length composition of tilapia fish for optimal usage and processing (Zaitsev *et al.,* 1969).

Manufacturing The Fish-Burger Samples

The manufacturing of the fish-burger samples was divided into two stages. To start with, the minced fish flesh was prepared from the crude fish and afterward manufacturing the fish-burger samples from the prepared minced fish flesh as described below:

Minced fish flesh preparation

In the first place, the weight and length composition of the selected fish was measured, then it was gently washed with tap water, beheaded, skinned, eviscerated, and deboned manually. The obtained fish flesh had been washed and drained properly. The minced fish flesh was carefully formulated by meat mincer (Moulinex Meat Mincer, 1mm holes diameter, ME 682827, France). All minced fish flesh samples were placed in a large stainless-steel bowl surrounded by crushed ice at 5 ± 1º C as shown in Fig (2) (Cao *et al.*, 2012).

Fish-burger preparation

Fish-burger samples were prepared according to the method explained by HassabAlla *et al*., (2009) and Cao *et al*., (2012) with some modifications. The chilled minced fish flesh was formulated and blended with the other ingredients as shown in Table (1). The produced mixture was manually shaped using a stainless burger maker to circular burgers of 10 cm diameter, 0.5 cm thickness, and 80 gm weight. Each piece was separated from the other using polyethylene layer before packaging in foam trays wrapped inside polyethylene bags. All samples were stored in freezer at -18 ± 1ºC until used. Samples in three replicates from each batch were subjected to cooking characteristics, physicochemical properties, proximate chemical composition, fatty acids, amino acids, microbial analysis, and sensory evaluation initially and periodically after cooking Figure (2).

Table 1. Ingredients of the fish-burger samples

Ingredient	%
Minced fish flesh	93%
White flour	3%
Spices Percentage (2%)	
Black pepper powder	0.25%
Cinnamon	0.25%
Cumin	0.25%
Thyme	0.25%
Garlic powder	0.5%
Onion powder	0.5%
Salt	1.5%
Sugar	0.5%
Total	100%

Cooking methods of prepared fish-burger

Three various cooking techniques (grilling, roasting, and frying) were objectively evaluated on the prepared fish-burger samples Figure (2). A double jacket electric grill (Sanduicheira, E- Grill Britania, 750W) for grilled burgers; pan fried burgers (Tefal - Hard Anodised 30cm Frying Pan) in corn oil; and roasted burgers in a Halogen convection oven (Cooks Professional, PRC, 1400W). All burgers cooked for 12 minutes at 180°C using three cooking techniques. Fish burgers were monitored using an infrared thermometer (IR GM300E, Germany) until they reached 77 °C in the center. The cooked fish-burgers were prepared just prior to the sensory evaluation and chemical assay**,** to identify the most convenient technique for cooking tilapia fish-burgers.

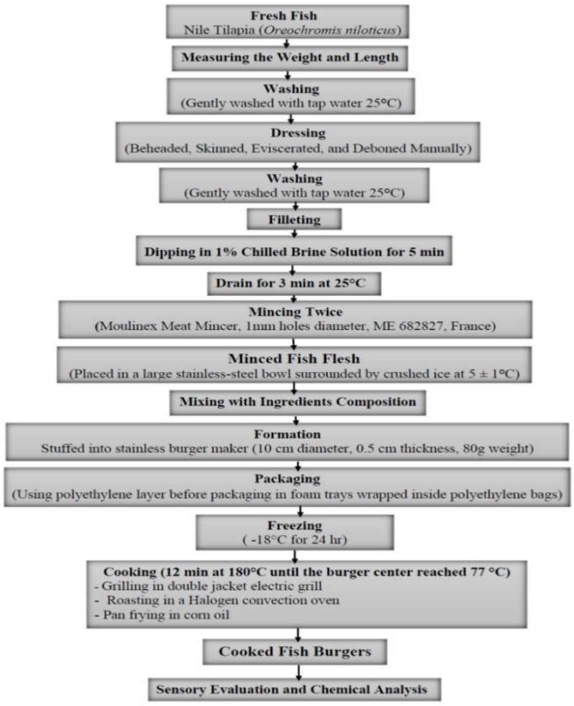

Fig .2. Flow chart of prepared Nile tilapia fish-burger

Quality Analysis

The quality of the prepared fish burgers was evaluated by physicochemical properties, cooking characteristics, chemical analysis, microbial activity**,** and sensory evaluation.

Cooking characteristics

Cooking characteristics (cooking yield, shrinkage value, fat retention, and moisture retention) of cooked fish burger were determined according to Alesson-carbonell *et al*., (2005).

Physicochemical properties

WHC (Water Holding Capacity) was determined using the press technique on 0.5 gram of fish burger calculated as (%) according to Aman (1983) and Oztan & Vural (1993); pH value was measured by pH meter (model GLP21, Crison instrument, European) using 10 gm of homogenized fish burger in 100 ml of distilled water (1:10 burger/water at 25 ºC); TVB-N (Total Volatile Base Nitrogen) calculated as mg/100 g; and TBARS (Thiobarbituric Acid Reactive Substances) calculated as mg malonaldehyde/kg were measured according to Pearson (1976) and AOAC (2016) .

Proximate chemical composition

Moisture content, crude oil, crude protein and ash contents were determined according to the AOAC (2016). Total carbohydrates value was calculated by differences. Calorific value was estimated as follows: for carbohydrate and protein 4 Cal per gram and for fat 9 Cal per gram (FAO/WHO, 1974).

Fatty acids composition

Fish lipids were extracted by Folch *et al*., (1957) as modified by Memon *et al*., (2011) then, the fatty acid methyl esters were prepared according to the method of AOAC (1995). The gas-chromatography (GC-FID) analysis of the fish oil samples was conducted using the Hewlett-Packard (HP6890) series system, with HP Chemstation software Rev A 09.01 (1206), and with a flame ionization detector (FID).

The esterified fat has been injected into the port of GC-FID apparatus with nitrogen carrier gas to identify and quantify fatty acids. Identification and quantification were based on a comparison with standards of retention time and peak areas.

Amino acids profile

Ion exchange chromatography was used to determine the amino acid concentration by TSM amino acid analyzer (Technicon Sequential Multisample; Dublin; Ireland) according to the method of (FAO/WHO. 1991). Two grams of sample was defatted by chloroform/methanol, and hydrolysed with HCl (6 M). In order to be separated and identified, the hydrolysate was then injected into a TSM analyzer. The content of tryptophan has not been established.

Microbiological assay

The microbial activities (total bacterial count, *Pseudomonas aeruginosa, Clostridium botulinum, Coliform bacteria, Salmonella & Shigella, Staphylococcus aureus*, and molds & yeasts count) were determined in control and cooked fish-burgers samples using the methods described by APHA, (1992 and 2005).

Sensory evaluation of cooked fish burger

Twenty trained panellists evaluated cooked fish burger samples. According to Tokur *et al*., (2004), a hedonic scale of 9-10 (excellent), 7-8 (good), 5-6 (fair), 2-4 (poor), and 1 (very poor) was employed. To conduct the sensory evaluations, fish burgers were randomly picked from frozen storage (-18^{o}C) for each test. In order to assess its sensory quality attributes, each panellist was served with a cooked fish burgers that had been cooked and cooled for 5 min at room temperature.

Cost-Profit Analysis of Nile Tilapia Fish Burger

On the basis of the market survey, a simple cost-profit analysis was done. In order to determine the commercial viability of the prepared fish burger, net profit and total cost of 100 burgers were estimated (Haq *et al*., 2013).

Statistical Analyses

The data was reported as means of triplicates± Standard Deviation (SD). At a degree of significance of $P \leq 0.05$, ANOVA (analysis of variance) was conducted as implemented in SAS software (SAS, Ver. 9.4). Tukey's test was used to assess mean differences (SAS, 2016).

RESULTS AND DISCUSSION

Technological Characteristics of Fresh Nile Tilapia (*Oreochromis niloticus*)

Weight and length assay

The fish's organs and tissues are not all edible, and each part has different chemical characteristics that make it valuable for other fish-based products (Zaitsev *et al*., 1969). Studies of fish's technological characteristics are important for the manufacturing process and the net output of a producer. These factors have a major effect on both the end product's cost and its profit margin.

The technological characteristics of selected fresh Nile tilapia fish are shown in Table (2). Forty-five fresh Nile tilapia fish were collected from Damietta fish market throughout the study period. The Nile tilapia, overall total weight 500 gm and measuring average 37.50 cm in length. In all, 52.13 % of the Nile tilapia was edible flesh part. On the other hand, skin, head, bones, viscera and tail represented 47.87% of the fish's total weight. Of the whole length of Nile tilapia fish, the trunk accounts 52.29%, followed by the head at 32.08 % and the tail at 15.63 %. These results have been in accordance with Uchiyama &Boggs; (2006); El-Zaeem *et al*., (2012); and Assefa& Getahun, (2014).

Table 2. Weight and length composition of Nile tilapia (*Oreochromis niloticus*)

Fish Part	Nile Tilapia Fish					
	Weight (gm)			Length (cm)		
	Range	Average	% Of overall weight	Range	Average	% Of overall length
Edible Part	259.61- 261.68	260.65 ±1.46	52.13	18.53-20.68	19.61±1.52	52.29
Skin	31.84-33.56	32.70 ±1.22	6.54	-	-	
Head	88.50-90.50	89.50 ±1.41	17.90	11.64-12.42	12.03±0.55	32.08
Bones	50.00-51.00	50.50 ±0.71	10.10	-	-	
Viscera	41.15-45.65	43.40 ±3.18	8.68	-	-	
Tail	21.95-24.56	23.26±1.85	4.65	5.29-6.42	5.86±0.80	15.63
Over all	450 -550	500.00±4.01	100	35-40	37.50±3.54	100

Values are shown as mean± standard deviations, n=45

Cooking characteristics attributes of cooked fish burger

Cooking characteristics of fish burgers were investigated by grilling, roasting, and frying, as illustrated in Figure (3). Cooking techniques such as frying, roasting, and grilling provided 88.42 %, 86.30 %, and 77.31 % of cooking yield; respectively. Grilled catfish burgers had a cooking yield of about 75 % according to Bochi & colleagues (2008). Roasted beef burger had a cooking yield value of about 73% as found by Aleson-Carbonell *et al*. (2005). Fish protein denaturation and coagulation during cooking promotes weight loss and fish burger shrinking. Shrinking was shown to be less in the grilled and fried burgers, but more in the roasted ones. Roasted burgers retained more moisture (81.43%) than grilled burgers (77.13%), while fried burgers retained less moisture (73.43 %) than grilled and roasted burgers. The fried fish burgers had significant high cooking yield, and low moisture retention. In general, a significant amount of moisture was lost from Nile-tilapia burgers cooked by frying, roasting, and grilling. A significant ($P \leq 0.05$) increase in fat retention was found in all cooked burger samples. The frying technique resulted in the lowest retention of moisture and highest retention of fat. Fried fish burgers had the highest fat content because frying method retained a larger amount of fat. There was a correlation between fat retention, moisture retention, and protein matrix's capability to hold water and/or bind fat. The previous outcomes were in line with previous investigations by Azad, (2001); Ejaz *et al*., (2009); HassabAlla *et al*., (2009); Talab, (2014); and Bainy *et al*., (2015).

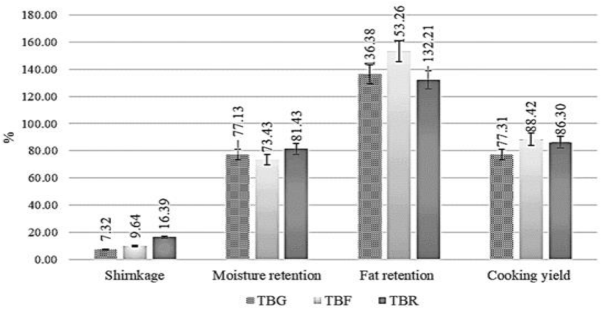

Fig .3. Cooking characteristics attributes of cooked tilapia fish burger

TBG: grilled tilapia fish burger, TBF: fried tilapia fish burger, TBR: roasted tilapia fish burger

Chemical Analysis

Chemical composition of fish burgers

The proximate chemical composition results of the cooked burgers are shown in Table (3). In the prepared fish burger, three different cooking techniques (frying, grilling, and roasting) were used. The moisture content of Nile tilapia burgers ranged from 72.07% of control burgers to 54.37% of corn oil fried burgers. Moisture content usually decreases with cooking. The initial moisture content in the cooked burgers was significantly ($P \leq 0.05$) lower than the control fish burgers. The moisture decrease in fried burgers is more evident and significant when compared to other cooked burgers.

Tilapia is a low-fat fish and fish fat content is affected by several factors such as age, species and nutrition as well as geographical location (Piggott &Tucker, 1990). Fatty fish is more susceptible to oxidation than lean fish, and species with greater amounts of unsaturated fatty acids are less stable (Upadhay & Das, 2006; and Ninan *et al.,* 2010). The fat content of control tilapia burgers was17.78%, whereas fried burgers had a fat content of 23.21%. On the other hand, the burgers' fat content increased as a result of the cooking method, with the increase being more noticeable in fried burgers. Cooking causes moisture loss in the burgers, which increases its fat content in most cases (Bainy *et al*., 2015). As for tilapia burger, it had an initial protein content of 44.15% for the control burgers, as well as 57.35%, 56.43%, and 55.50% for fried, grilled and roasted; respectively. Fried burgers had a higher protein level than other methods of cooking.

Cooked burgers lose moisture which result in an increase in protein, fat, and ash contents. The grilling method caused lower moisture loss than frying and higher than roasting. This can be correlated to the cooking method temperature and the rate of burger temperature. The reduction in moisture content has been regarded as the most obvious alteration that causes overall fat, protein, and ash levels to rise significantly. In addition to oil adsorption and moisture loss, fish burgers may have a high fat content due to the cooking technique. It is possible that evaporation will offset part of the fat loss (Saguy & Dana, 2003). Ravindranathan *et al.,* (1982) found that fish burgers prepared by frying had a higher total fat content than comparable fish pastes.

The carbohydrate**s** content (based on dry weight) of control tilapia burgers was 30.74%, whereas roasted, grilled, and fried burgers had a carbohydrate**s** content of 14.58%, 13.48%, and 10.20%, respectively. Glycogen is a form of carbohydrate, makes up a tiny part of the fish's chemical composition (Babalola *et al*., 2011). Prior studies have revealed that the contents of fish carbohydrates are low as estimated and determined from the difference between other components, which is well-known in the fish industry. According to Nurnadia and Colleagues (2011), *F. sardinella* contains 3 % carbohydrates on wet basis. The carbohydrate content of five fish species (*S. aurita*, *C. gariepinus*, *M. furnieri*, *T. trachurus*, and *S. scombrus*) ranged from 1.6 to 4.6 % on wet basis in Nigeria. in this study. According to the results, the control tilapia fish burger included a high percentage of carbohydrates, which may be attributed to the use of white flour (3%) and sugar (0.5%) in the prepared tilapia fish burger mixture. The carbohydrate content was decreased in the processed fish burgers following the three cooking techniques which could be explained by the increase in protein, fat, and ash contents as well as moisture loss during the cooking procedure. Caloric values of cooked fish burgers showed significant differences ($p \leq 0.05$), which may be related to the effect of cooking technique. This was consistent with prior studies by Filho (2009); and Vanitha *et al.,* (2015).

The proximate chemical composition of roasted and grilled burgers did not differ significantly ($p \leq 0.05$), indicating that the both cooking methods did not affect the chemical composition of the end product. However, the frying technique and both other cooking techniques differs significantly ($p \leq 0.05$). Talab (2014) reported similar findings for fried, grilled, and backed catfish burgers, as well as grilled and backed tilapia burgers by Bainy *et al.,* (2015). Also, comparable results have been observed by Garca-Arias *et al*., (2003) and Weber *et al*., (2008) for grilled, roasted sardines and catfish fillets.

Table 3. Changes in proximate chemical composition of cooked tilapia fish burgers

Factor (%)	**Cooking Method**				
	TBC	**TBG**	**TBF**	**TBR**	**LSD**
Moisture *	$72.07^{a}\pm0.62$	$65.89^{b}\pm0.82$	$54.37^{c}\pm1.49$	$66.71^{b}\pm0.27$	1.161
Protein**	$44.15^{b}\pm0.54$	$56.43^{a}\pm0.58$	$57.35^{a}\pm0.58$	$55.50^{a}\pm0.53$	2.867
Fat **	$17.78^{c}\pm0.77$	$21.78^{b}\pm0.38$	$23.21^{a}\pm1.41$	$20.99^{b}\pm0.67$	1.452
Ash **	$7.33^{c}\pm1.15$	$8.31^{b}\pm0.10$	$9.24^{a}\pm0.48$	$8.66^{b}\pm1.15$	0.412
Carbohydrates **	$30.74^{a}\pm0.95$	$13.48^{b}\pm0.87$	$10.20^{c}\pm1.53$	$14.58^{b}\pm2.19$	1.537
Calorific Value** (Cal/100gm)	$459.58^{c}\pm4.30$	$475.66^{ab}\pm1.92$	$478.37^{a}\pm8.39$	$469.23^{b}\pm2.39$	2.932

Values are shown as mean± standard deviations, n=3. * = on wet base, **= on dry base

Means in a raw which are followed by the same letter are not significantly differed ($p \leq 0.05$)

TBC: control tilapia burger; TBG: grilled tilapia burger; TBF: fried tilapia burger; TBR: roasted tilapia burger

Physicochemical properties, TVB-N, and TBARS of cooked tilapia fish burgers

pH value, WHC, TVB-N, and TBARS are all affected by the cooking technique, as shown in Figure (4). Fried, grilled, and roasted tilapia fish burgers had pH values of 6.56, 6.52, and 6.51, respectively. After cooking the pH values indicated a non-significant ($p \leq 0.05$) slight rise. The fried burger had a pH of 6.56 compared to the control tilapia burgers' pH of 6.41. In terms of pH, there were no significant differences ($p \leq 0.05$) between control and cooked burgers. According to Vanitha *et al*., (2015), pH of catla fish burgers was between 6.10 and 6.80. Talab (2014), reported pH values for raw, microwave, fried and roasted cutlets of carp fish 6.15, 6.20, 6.23, and 6.25, respectively. Bainy *et al*., (2015), observed that the tilapia cooked burgers' pH increased to 6.30 compared to the pH of 6.10 for the raw burgers. Numerous studies reported varied outcomes about pH reduction or rise in freshwater fish species. pH value of 6.80 to 7.00 was recommended as the acceptability range for fish, while values over 7 were regarded as spoilt (Orak & Kayisoglu, 2008). Fish post-mortem pH can vary from 5.40 to7.20, depending on fish species (Grigorakis *et al.*, 2003). The findings were analogous to Bett & Dionigi (1997), who concluded that pH of fish flesh increased during the post-mortem period due to a breakdown of the nitrogen components. The raised fish pH value might be linked to the production of the fundamental bacterial growth components (Simeonidou *et al*., 1998). In addition, the rise in pH might be due to the hydrogen bonding and electrical interaction (Dhanapal *et al*., 2012).

Tilapia burgers were found to have initial WHC (water holding capacity) values of 71.30 % for control burgers, as well as WHC values of 67.47%, 66.74%, 64.06 % for grilled, roast, and fried fish, respectively. For the grilled burgers, the WHC value was determined to be 67.47%, which is close to the 66.74% observed for the roasted burgers. There were no significant ($p \leq 0.05$) differences in the WHC values of roasted and grilled burgers. However, the frying technique and both other cooking techniques differs significantly ($p \leq 0.05$). Cooked burgers had a high significant moisture retention and WHC content, indicating that the formula employed in this study had strong gelling properties entrapping fat and moisture in its matrix. There is no doubt about the freshwater fish's ability to generate gel- emulsions when a 1.5 % salt concentration is used in the current formulation (Vanitha *et al.*, 2015). As a result of cooking, WHC of fish burgers may decrease due to numerous factors such as protein denaturation, enzymatic processes and activities, lipid peroxidation and degradation, and microbial activities (Bainy *et al.,* 2015).

A general indication of fish flesh deterioration is Volatile Basic Nitrogen (TVB-N). It consists mostly of ammonia, dimethylamine, trimethylamine and other volatile amine spoilage combinations. In freshwater fish there is no trimethylamine thus there are alternative substrates (Fan *et al*., 2008). As a result, TVB-N values of control fish burgers, fried, grilled, and roasted were determined to be 13.77, 12.36, 11.93, and 11.87 (mg/100 g); respectively. The control fish burgers scored the highest TVB-N value (13.77 mg/100 g), and the lowest TVB-N value (11.87 mg/100 g) in roasted fish burgers. There were significant differences ($p \leq 0.05$) between control and cooked burgers while the three cooking techniques did not show significant changes ($p \leq 0.05$) in TVB-N values. Varlik *et al*., (1993), stated that a TVB-N value below 25 mg/100 g fish product can be safely consumed and that a level 35 mg/100g and above is not consumable. During frozen storage, TVB-N value can be altered depending on storage temperature, species, cooking method, and processing techniques (Tokur *et al.*, 2006).

The value of thiobarbituric acid reactive substances (TBARS) is based on the TBA reaction with malonaldehyde which results in two TBA molecules condensed by a malonalddehyde-molecule and two possible water molecules eliminated to produce a red pigment. TBARS levels should not be considered a reference value for fish general rancid odor, as the value of TBARS can be affected by factors such as species, age, food processing, storage period, and cooking procedure (Fernandes *et al.*, 1997). Schormuller (1969) has indicated that the level of the TBARS is acceptable for good and acceptable fish products should be below 3 up to a maximum of 7 mg malonaldehyde / kg. TBARS value of cooked burgers were generally non-significant lower ($p \leq 0.05$) than control burgers (Figure 4). Roasted fish burgers were the lowest TBARS value (1.51 mg malonaldehyde/kg), followed by grilled (1.58 mg malonaldehyde/kg) and finally fried burgers (1.67 mg malonaldehyde/kg). The TBARS values were not significantly ($p \leq 0.05$) changed when comparing the three cooking techniques. The decrease in the level of TBARS in fish burgers affected by cooking techniques can be caused by the interaction between malonaldehyde and protein breakdown products to produce tertiary compounds (Hernandez-Herrero *et al*., 1999). According to Taskaya *et al*., (2003); Tokur *et al.,* (2004); Mahmoudzadeh *et al*., (2010); Vanitha *et al.,* (2015); and El-Dengawy *et al*., (2017) who observed the similar pattern of data on fish burgers, these findings are consistent.

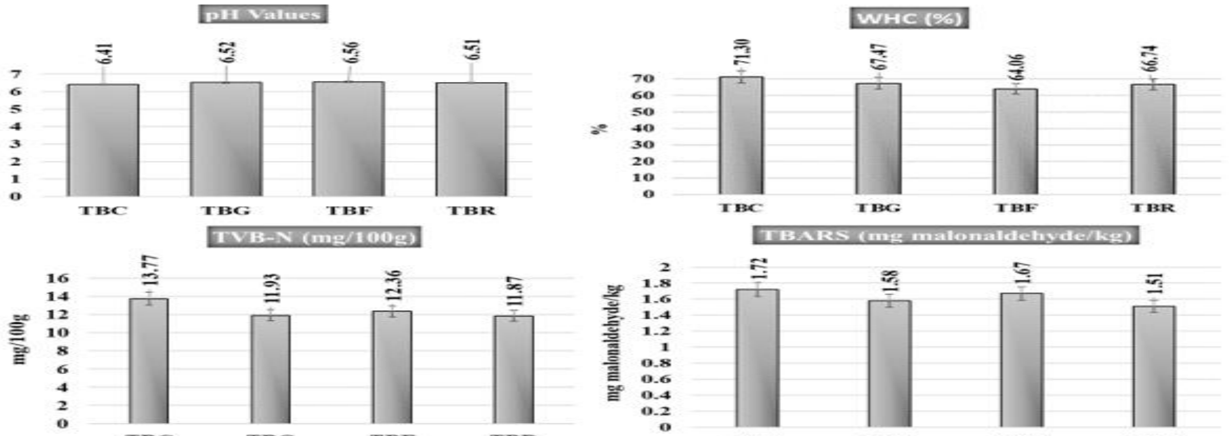

Fig .4. Physicochemical properties, TVB-N, and TBARS of cooked tilapia fish burgers
TBC: control tilapia burger; TBG: grilled tilapia burger; TBF: fried tilapia burger; TBR: roasted tilapia burger

Fatty acids composition of cooked tilapia fish burgers

Long-chain omega-3 polyunsaturated fatty acids, such as DHA (docosahexaenoic acid), and EPA (eicosapentaenoic acid), are abundant in fish lipids Gomma *et al*., (2020). The essential fatty acids α-Linolenic acid and linoleic acid can be converted into EPA and DHA. EPA and DHA content in tilapia fish burgers were not quantified, but the fatty acid composition indicated that the two essential fatty acids were present in significant amounts. Control tilapia burgers contain 10.95 % and 6.69 % α-Linolenic and linoleic acids; respectively. However, these values may vary in cooked burgers. Fish burgers include more than just EPA and DHA; they're rich with a range of other fatty acids. Tilapia burgers are high in oleic and palmitic acids. Control fish burgers have 63.90 % more unsaturated fatty acids than saturated fatty acids (36.10 %). Bowman & Rand, (1991) and Gibson, (1983) have discovered that PUFAs enhance wound healing and regulate prostaglandin production, and the ω3 and ω6 PUFAs have been found to make a significant contribution to the treatment of cancer, as well as cardiovascular disease (Connor, 1997). Fish and fish products are rich in polyunsaturated fatty acids, thus increasing the diet of fish products can be advantageous (Sargent, 1997). Some fish species, including marine and freshwater species, may have a different composition of PUFAs than others. This study's results indicate that the composition of the Nile tilapia fish differed from that of other fish species.

In both control and cooked fish burgers, oleic, palmitic, α-linolenic, palmitoleic, linoleic, and stearic acids were the most prevalent fatty acids (Table 4). Lauric acid and arachidic acid, on the other hand, contained trace amounts. It was shown that cooking methods, particularly frying, had an impact on the fatty acid composition of cooked fish burgers. Linoleic, myristic, erucic, lauric, and arachidic acid levels of the fried burgers increased significantly ($p \leq 0.05$). Grilled fish burger showed some decrease in palmitic acid and a significant rise of α-Linolenic acid, while palmitoleic acid remained unchanged. However, the observed changes of investigated cooked fish burger were not homogeneous for fatty acid composition because some reduced, some increased, and others did not affect. Cooked Nile tilapia burgers fatty acids profile findings were in line with those published previously by Garcia-Arias *et al*., (2003); and Oluwaniyi *et al., (*2010).

Table 4. Fatty acids composition of cooked tilapia fish burgers

Fatty Acids (% of total fatty acids)	TBC	TBG	TBR	TBF	LSD
Saturated fatty acid (SFA)					
Lauric acid (C12:0)	0.00±0.00[c]	2.02±0.10[b]	0.00±0.00[c]	3.91±0.04[a]	0.196
Myristic acid (C14:0)	0.33±0.05[c]	1.62±0.04[b]	0.36±0.06[c]	6.32±0.02[a]	0.316
Palmitic acid (C16:0)	27.36±3.05[b]	26.94±2.78[b]	29.89±2.13[a]	23.98±1.99[c]	1.493
Margaric acid (C17:0)	1.88±0.02[b]	2.33±1.06[a]	2.01±0.08[a]	1.12±0.12[c]	0.100
Stearic acid (C18:0)	5.66±0.26[a]	5.85±0.21[a]	5.92±0.31[a]	4.62±0.29[b]	0.296
Arachidic acid (C20:0)	0.00±0.00[b]	1.11± 0.03[a]	0.00±0.00[b]	1.16±0.02[a]	0.058
Behenic acid (C22:0)	0.89±0.33[b]	1.35±0.52[a]	0.91±0.03[b]	0.49±0.06[c]	0.025
Unsaturated fatty acid (USFA)					
Palmitoleic acid (C16:1)	10.07±1.05[a]	9.98±1.11[a]	10.35±1.34[a]	5.65±0. 94[b]	0.518
Oleic acid (C18:1)	30.34±2.98[a]	26.99±3.01[b]	26.27±2.45[b]	27.35±2.34[b]	1.517
Linoleic acid (C18:2)	6.69±1.78[b]	5.11±1.55[c]	7.10±1.05[b]	14.79±1.66[a]	0.740
α-Linolenic acid (C18:3)	10.95±2.22[a]	11.01±2.16[a]	11.21±2.06[a]	4.52±2.13[b]	0.561
Arachidonic acid(C20:4)	2.27±0.34[a]	2.01±0.89[a]	2.22±0.56[a]	1.22±0.76[b]	0.114
Erucic acid (C22:1)	3.60±1.11[b]	3.68±1.56[b]	3.76±1.45[b]	4.87±1.19[a]	0.244
Total (%)					
Fatty acids	100.00	100.00	100.00	100.00	
Saturated fatty acids	36.10±5.45[b]	41.22±3.08[a]	39.09±2.45[ab]	41.60±3.11[a]	2.080
Unsaturated fatty acids	63.90±2.74[a]	58.78±2.93[b]	60.91±1.67[a]	58.40±1.11[b]	3.195

Values are shown as mean± standard deviations, n=3.
Means in a raw which are followed by the same letter are not significantly differed ($p \leq 0.05$); LSD at ($p \leq 0.05$)
TBC: control tilapia burger; TBG: grilled tilapia burger; TBF: fried tilapia burger; TBR: roasted tilapia burger

Amino acids profile of cooked tilapia fish burgers

The data of amino acids profile of cooked tilapia fish burgers, presented in Tables (5). The results showed that glutamic, aspartic, and leucine acid concentrations were significantly increased ($p \leq 0.05$), whereas cysteine and methionine concentrations were decreased in all cooked burgers. Nile tilapia is an excellent source of essential amino acids for people of all ages and should be consumed by everyone. On average, essential amino acids made up 37.63% of control samples, followed by acidic amino acids (27.42%), aromatic amino acids (9.44%), and sulfur amino acids (4.59%). When comparing the three cooking techniques, the amount of essential amino acids, acidic amino acids, aromatic amino, and sulfur amino acids did not show a significant difference ($p \leq 0.05$).

The total sulfur amino acids of tilapia burgers decreased significantly ($p \leq 0.05$) after cooking. When analyzing amino acids of fried burgers, the results did not show a significant increase (p ≤ 0.05) in total essential amino acids, and total aromatic amino acids, but there was significant ($p \leq 0.05$) decrease in sulfur-containing amino acids and total amino acids, nevertheless a significant ($p \leq 0.05$) increase in acidic amino acids. These findings are in line with those of Oluwaniyi *et al., (*2010) and Rani & Colleagues (2017).

The effects of cooking process on the amino acid and protein composition of fish samples have been documented by other researchers. In contrast to Ismail *et al*., (2004), who found that frying and boiling had no significant effect on protein and amino acids level, another group found that heat processing reduced protein value by destroying or rendering inaccessible the constituent amino acids (Burger &Walters, 1972). According to this, a change in amino acid concentration in fish samples might potentially be a result of heat treatment time and cooking technique. Oluwaniyi *et al*., (2010) found that roasting and boiling had no significant effect on the amino acid composition of the fish, but deep-frying resulted in a significant drop in essential, sulfur, and aromatic amino acids. In conclusion, these results demonstrate that processing has a wide range of effects on different fish species, with frying having the greatest negative effects in terms of protein content. Unless they are fried, marine water fishes do not have any limiting amino acids. Foods with a higher protein content may not necessarily be of higher quality. This idea holds that tissues protein synthesis is restricted since all essential amino acids are present simultaneously and in suitable proportions at the point of tissue protein biosynthesis.

Table 5. Amino acids profile of cooked tilapia fish burgers

Amino Acid (g/100 g protein)	TBC	TBG	TBR	TBF	LSD
Glutamic	12.25±2.34^{b}	12.44±2.04^{a}	12.53±1.94^{a}	12.39±1.87^{a}	0.662
Aspartic	9.62±1.11^{b}	10.16±1.09^{a}	10.38±0.95^{a}	10.15±1.21^{a}	0.519
Leucine	6.30±1.90^{b}	6.94±1.45^{a}	6.80±1.05^{a}	6.61±1.67^{a}	0.347
Arginine	5.72±0.67^{a}	5.37±0.93^{b}	5.55±0.78^{a}	5.35±0.99^{b}	0.278
Alanine	5.58±1.06^{a}	5.50±1.22^{a}	4.82±1.07^{b}	4.66±1.88^{b}	0.279
Lysine	5.28±1.44^{a}	4.86±1.65^{b}	4.63±1.89^{b}	4.37±1.11^{c}	0.264
Glycine	4.97±1.11^{a}	4.82±1.09^{a}	4.74±1.86^{a}	4.59±1.33^{b}	0.249
Phenylalanine	4.29±1.89^{b}	4.58±1.25^{a}	4.45±1.78^{a}	4.29±1.26^{b}	0.229
Serine	3.49±0.56^{a}	3.58±0.98^{a}	3.26±0.77^{b}	3.04±0.49^{b}	0.179
Proline	3.47±1.90^{a}	3.63±1.45^{a}	3.53±1.12^{a}	3.33±1.09^{b}	0.182
Isoleucine	3.27±1.22^{b}	3.51±1.73^{a}	3.22±1.05^{b}	3.17±1.52^{b}	0.176
Valine	3.25±1.05^{b}	3.76±1.17^{a}	3.51±1.82^{a}	3.37±1.21^{b}	0.188
Tyrosine	3.24±0.96^{a}	3.32±0.48^{a}	3.16±1.01^{b}	3.00±0.84^{c}	0.166
Threonine	3.08±1.09^{b}	3.30±1.34^{a}	3.22±1.27^{a}	3.08±1.87^{b}	0.165
Histidine	2.28±1.08^{a}	2.32±1.43^{a}	2.36±1.81^{a}	2.18±1.09^{b}	0.168
Methionine	2.26±0.44^{a}	1.92±011^{b}	1.87±0.53^{b}	1.84±0.22^{b}	0.113
Cystine	1.50±0.45^{a}	1.03±0.83^{b}	1.16±0.91^{b}	1.00±0.83^{b}	0.062
Total (%)					
AA	79.75±3.45^{a}	81.04±2.99^{a}	79.19±3.04^{a}	76.42±2.78^{b}	4.052
EAA	37.63±2.56^{a}	38.49±1.99^{a}	37.96±1.83^{a}	37.83±2.03^{a}	1.921
AAA	27.42±1.98^{b}	27.89±2.34^{a}	28.93±1.95^{a}	29.49±2.11^{a}	1.455
SAA	4.59±0.96^{a}	3.64±0.78^{b}	3.83±0.92^{b}	3.72±0.78^{b}	0.203
ARAA	9.44±0.79^{a}	9.75±0.06^{a}	9.61±0.11^{a}	9.54±0.34^{a}	0.487

Values are shown as mean± standard deviations, n=3.

AA: Amino acids, EAA: total essential amino acids, AAA: total acidic amino acids, SAA: total sulfur amino acids, ARAA: total aromatic amino acids

Means in a raw which are not followed by the same letter are significantly differed (*$p \leq 0.05$*)

Microbial Activities of Cooked Tilapia Fish Burgers

The changes in total bacterial count, *Pseudomonas aeruginosa, Clostridium botulinum, Coliform bacteria, Salmonella & Shigella, Staphylococcus aureus*, and molds & yeasts count of control, and cooked Nile tilapia fish burgers are illustrated in Figure (5). The total bacterial count of control, roasted, grilled, and fried cooked tilapia fish burgers was 3.62, 2.25, 2.22 and 2.25 (log CFU/g), respectively. The data indicated a downtrend with cooking processes. The total bacterial count, as well as the total *coliform bacteria*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, mold, and yeast counts, reduced significantly ($p \leq 0.05$) in all cooked fish burgers. On the other hand, *Clostridium botulinum, Salmonella and Shigella* were not identified in prepared tilapia fish burgers. Previous study on tilapia fish found that the microbial load in fish burgers was higher than in minced flesh which might be attributed to the usage of some ingredients and manufacturing procedures in the burger preparation (Lithi *et al*., 2020).

The reduction and variability in the microbial load of cooked fish burgers can be attributed to the heating and cooking process. Ninan *et al*., (2010) and Talab, (2014) showed comparable reduction in the number of total bacterial count. Talab (2014) found that the total bacterial count of carp cutlets raw and cooked using a halogen oven, microwave, and deep frying were 3.2, 2.6, 2.7, and 2.8 log CFU/g, respectively. Another study found that the total bacterial count and yeasts & molds of fresh tilapia fish were 2.25 and 10.6 log CFU/g, respectively, and increased to 3.5 and 12.5 log CFU/g, respectively, after deep frying in sunflower oil for 10 min at 180°C without exceeding the permissible microbial load (Mohamed *et al*., 2019). The current study found that pan fried fish burgers contained coliform bacteria, mold, and yeast, which could be linked to the high lipid content and other fried burger ingredients, as it had a long-term influence on the death rate of these microbials. According to the ICMSF, fresh fish and fish sticks are allowed to have a maximum microbial load of 10^7 CFU/g (ICMSF, 1978). Fish burgers had no standard microbiological load, while hamburgers had a maximum of 10^6 CFU/g (Anonymous, 1992). According to the findings, tilapia burgers prepared under excellent manufacturing practices and safe to eat in all cooking methods.

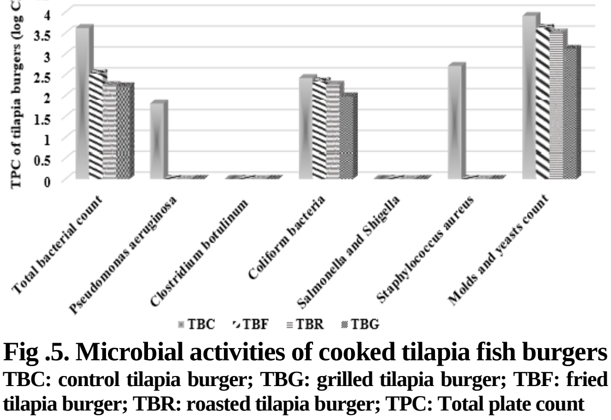

Fig .5. Microbial activities of cooked tilapia fish burgers
TBC: control tilapia burger; TBG: grilled tilapia burger; TBF: fried tilapia burger; TBR: roasted tilapia burger; TPC: Total plate count

Sensory Evaluation of Cooked Tilapia Fish Burgers

Sensory characteristics (color, taste, odor, texture, appearance, and overall acceptability) of prepared tilapia fish burgers were evaluated as illustrated in Figures (6). Sensory assessment of fish products is becoming more common in quality assurance, marketing research, and product development. Psychological techniques are used to assess the physical characteristics of food. The human tasting panel is the gold standard when it comes to objective judgments (Gould & Peters, 1971). It is generally known that the sensory value of fish varies considerably depending on species, storage conditions, temperature, whether the product is fresh processed or fresh, and cooking technique. Each quality criterion's permissible limitations will thus vary based on the product's kind (Kose & Uzuncan, 2000).

A statistically significant difference ($p \leq 0.05$) existed between the three cooking methods in terms of color, taste, texture, odor, appearance, and overall acceptability. Compared to beef or chicken, tilapia burgers have a smoother texture. Fried and grilled burgers had better taste, color, odor, texture, appearance, and overall acceptability than roasted burgers. Panelists rated fried burgers top in terms of color (8.53), taste (7.93), odor (8.37), texture (8.53), overall acceptability (9.21), and appearance (9.11). The differences in the sensory qualities of burgers emphasize the superiority of fried burgers over other cooked burgers. This may be attributed to the impact of oil and frying heat on the texture, color, and flavor enhancement of the product to match their texture and flavor of fish burger. Despite the fact that fried fish burgers had a lower nutritional value, panelists preferred them because of their appetizing flavor and taste. As a whole, the three cooking techniques in the zone of the panelists' approval.

On the basis of sensory evaluation and data on the quality of cooked burgers, it was revealed that Nile tilapia fish flesh may be used to make a value-added product such as burger. It is a medium size fish with a high flesh content that is available all year round in Egypt. Fish like tilapia, with its high flesh yield, as well as its nice flavor, color, and texture, is well-recognized as a quality raw material for burgers.

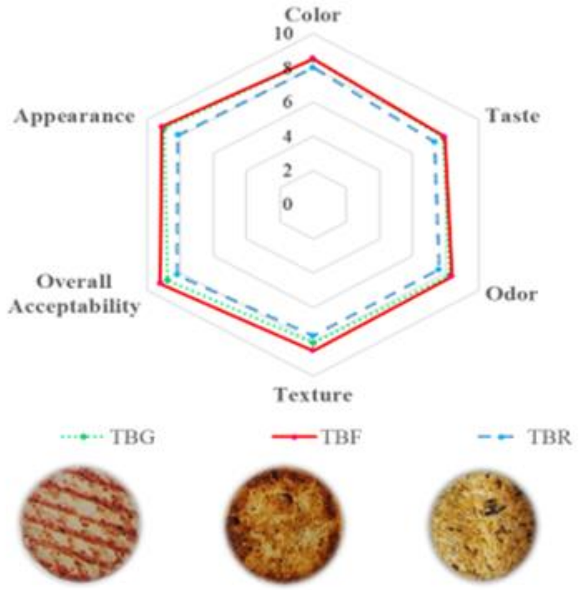

Fig .6. Sensory attributes of cooked tilapia fish burgers
TBG: grilled tilapia burger; TBF: fried tilapia burger; TBR: roasted tilapia burger

Cost- Profit Assay

The cost-profit assay was presented in Table (6). Approximate 7.50 kg of minced fish flesh were obtained from 14.5 kg of Nile tilapia fish mixed with other ingredients 0.57 kg. This minced fish flesh mixture was used to prepare 100 burgers (80 grams for each burger). The manufacturing cost was 6 EGP for each burger. The maximum purchase price in the local market for the fish burger was 11 EGP with a net profit of 500 EGP. The profit margin for the Nile tilapia fish burger was 83.33%. These findings were in line with Haq *et al.,* (2013). Current research suggests Nile tilapia fish may be utilized effectively to make value-added products such as fish burgers, which are popular with customers. When low-value fish like tilapia can be turned into profitable products, fishermen may make more money from their harvest. Customers will also benefit from more affordable and higher-quality fish products that match their fast-food lifestyle.

Table 6. Cost profit analysis of Nile tilapia fish burgers

	Cost			Profit				
Factor	**Unit cost (EGP/Kg)**	**Amount (kg)**	**Total cost (EGP)**	**Burgers number**	**Maximum retail unit price (EGP)**	**Total retail price (EGP)**	**Net profit (EGP)**	**Profit (%)**
Fresh fish	30	14.50	435					
Minced fish flesh	-	7.50	-	100	11	1100	500	83.33%
Other ingredients	-	0.57	165					
Total		8.07	600					

EGP = Egyptian Pound

CONCLUSION

In this study, three different cooking techniques (pan frying in corn oil, roasting in a Halogen convection oven, and grilling in a double jacket electric grill) were used, and their influence on the quality attributes (cooking characteristics, chemical analysis, physicochemical properties, microbiological activity, and sensory evaluation) of fish burgers was examined. Shrinking was shown to be less in the grilled and fried burgers, but more in the roasted ones. The frying technique resulted in the lowest retention of moisture and highest retention of fat. There were no significant ($p \leq 0.05$) differences in the proximate chemical composition of roasted and grilled burgers. However, the frying technique and both other cooking techniques differs significantly ($p \leq 0.05$). In terms of pH, TVB-N, and TBARS values, there were no significant differences ($p \leq 0.05$) between the three cooking techniques. During the frying process, the fatty acids and amino acids content of the burgers was considerably influenced. The total bacterial count, as well as the total coliform bacteria, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, mold, and yeast counts, reduced significantly ($p \leq 0.05$) in all cooked fish burgers. On the other hand, *Clostridium botulinum*, *Salmonella* and *Shigella* were not identified in prepared tilapia fish burgers. The results of a sensory evaluation of fish burgers revealed that fried and grilled burgers had better taste, color, odor, texture, appearance, and overall acceptability than roasted burgers. The cooking procedure changed the texture and color of roasted and grilled tilapia fish burgers, but not their nutritional content. Preparing burgers from low-cost fish with profit margin about 83.33%, according to the current study, would pave the way for optimal exploitation of this product, especially during the peak fishing season which increase the producer economic benefits.

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تأثير ثلاث تقنيات للطهي على خصائص جودة برجرسمك البلطي النيلي(*Oreochromis niloticus*)

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تهدف تلك الدراسة الى تقييم تأثير ثلاث تقنيات للطهي (القلى فى زيت الذرة و التحمير فى فرن الهالوجين والشوى فى الشواية الكهربائية) على صفات الجودة (خصائص الطهى والتركيب الكيماوى والخصائص الفيزوكيميائية ومحتوى الأحماض الدهنية و الأحماض الأمينية والنشاط الميكروبى و التقييم الحسي) لبرجر سمك البلطي النيلي (*Oreochromis niloticus*) بالأضافة لتقديرالجدوى الاقتصادية للمنتج. استخدم فى هذة الدراسة سمكة البلطى النيلى بمتوسط وزن 500 جرام و كان نسبة الفيليه المستخرج منها 52٪ تقريبا. أوضحت نتائج الدراسة ان تقنيتى الشوى والتحمير لم يكن لهما تأثير معنوى ($p \leq 0.05$) على التركيب الكيماوى لبرجر سمك البلطى فى حين لوحظ فروق معنوية ($p \leq 0.05$) بين تقنية القلى و تلك الطريقتين. لم يكن لتقنيات الطهى الثلاثة تأثير معنوى ($p \leq 0.05$) على كلا من قيم الأس الهيدروجينى و النيتروجين المتطاير الكلى وحمض الثيوباربيتوريك. بينما كان لتقنية القلى تأثير معنوى على محتوى الأحماض الدهنية والأحماض الأمينية لبرجر السمك. وقد اشارت نتائج التقييم الحسي أن طرق الطهى الثلاثة نالت قبول المحكمين بشكل عام .وكان برجر السمك المقلي والمشوي اكثر تقبلا من قبل المحكمين من حيث اللون والرائحة والطعم والمظهروالقوام والتقبل العام مقارنة بالبرجر المحمر بالفرن. و خلصت الدراسة إلى أن برجر السمك ذو قيمة غذائية عالية ومفيد للأنسان ويمكن طهيه فى الشواية الكهربائية أو فى فرن الهالوجين دون تأثير على قيمته الغذائية مع اعتماد تلك الطريقتى ضمن النظام الغذائي الصحي. كذلك هذه الدراسة تمهد الطريق لتصنيع وانتاج برجر سمك البلطى النيلى بهامش ربح تقريبي 83٪ بهدف الاستفادة المثلى من سمك البلطى خاصة خلال ذروة موسم الصيد.