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Impact of cooking methods and frozen storage on quality parameters of mullet fish (*Mugil cephalous*) steaks.

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Abstract

The present study was carried out to investigate the changes in quality parameters such as physicochemical and microbiological parameter of mullet fish (*Mugil cephalous*) steaks by frying and grilling cooking method and during frozen storage at -18°C for 6 months. TVB-N and TBA of fresh mullet fish steaks were slightly decreased after cooking process while the pH value showed slightly increase after cooking process. The lowest TBC and Y&M were observed in the fried samples as compared with raw mullet fish followed by grilled samples. TVB-N and TBA contents of raw and cooked mullet fish samples gradually and significantly ($p<0.05$) increased as the storage period extended while pH value slightly increased during storage period. The values of TBC showed wavy progress for both raw mullet fish and cooked samples. The microbiological analysis showed no detection of mold and yeast in the fried and grilled mullet fish samples could be found expect in the raw sample after 2.0 months.

Keywords: *Mullet fish, Cooking methods, Frying, Grilling, Frozen storage.*

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Introduction

Fish and fishery products have long been recognized as healthy foods with excellent nutritional value, providing high-quality protein, minerals, vitamins, essential fatty acids and trace elements. Fish is widely consumed in many parts of the world by humans due to its high content of good protein that charatrizes by an excellent amino acid composition and easily digestibility [1]. Freezing is a preferred technique to preserve fish and fish products for long time. It permits to preserve the flavor and the nutritional properties better than storage above the initial freezing temperature. It also has the advantage of minimizing the microbial and enzymatic activities [2]. Freezing should take place as soon as possible after the fish is slaughtered, preferable before onset of rigor mortis. All intermediate storage will result in lower quality and reduced shelf-life after freezing. If immediate freezing for some reason, such as transport, filleting and processing, is not possible, chilling should take place immediately after catching and product temperatures below 0°C should quickly be reached. Fish is usually cooked in different ways such as boiling, baked, frying and grilling. These cooking methods result in enhancing flavor, taste and improve the digestibility and inactivate the pathogenic microorganisms [3]. During cooking of fish, some chemical and physical reactions take place such as protein denaturation that increases its digestibility and improves the nutritional value. Meanwhile, the contents of thermolabile compounds, fat-soluble vitamins or polyunsaturated fatty acids are often reduced [4]. Quality losses in fresh fish products depend to a large extent on micro-organisms present in or around the products. The metabolism of the micro-organisms will mostly terminate in frozen conditions. The microorganisms and biochemical changes are responsible for enzymatic breakdown of protein to several compounds that accumulated resulting in the deterioration and spoilage of the product [5]. Total volatile basic base-nitrogen (TVB-N) content is used to assess the quality of raw and frozen fish products. According to [6] seafood was evaluated as 'very good', if TVB-N value is lower than 25 mg/100 g; 'good', if TVB-N value is between 25-30 mg/100 g, 'marketable', if TVB-N valueis between 30-35 mg/100 g and 'spoiled', if TVB-N value is 35 mg/100 g or higher than this value. Similar statements were reported by previous studies [7,8]. TBA the most important limiting factor during frozen storage of fish (especially fatty species) is the oxidation of lipids stored in muscle tissue of fish [9]. Increases and decreases in the value of TBA, particularly during long-term storage, are observed as the secondary products of lipid oxidation [10,11].

Materials and Methods

Mullet fish (Mugil cephalus)

Fresh mullet fish (*Mugil cephalus*) was obtained from Wadi El-Rayan Lake during February 2016. Averages of weight and length ranged between 1.3-1.5 kg and 46-52 cm, respectively. Mullet fish samples were kept in an ice-box and transported to the laboratory of Fish Processing Technology, Shakshouk Station for Fish Research, National Institute of Oceanography and Fisheries, Fayoum Governorate, Egypt. The fish samples were beheaded, gutted and cut into steaks then washed gently with tap water. The prepared raw fish steaks samples were divided into four groups and packed in polyethylene bags then stored at -18°C for 6.0 months. At intervals of 2.0 months, samples of frozen fish fillets were withdrew, thawed and cooked with two methods; frying and grilling.

Cooking methods

Frying and grilling cooking methods were carried out on the pre-frozen mullet fish steaks at zero time of storage and at intervals of 2.0 months.

Frying: Frozen mullet steaks were thawed, soaked in saturated salt solution for two minutes, and then spices mixture was put in the steaks cavity and rubbed with flour. The steaks were fried in sunflower oil heated at 180°C for 5 minutes for each side of the steaks using electrical fryer pan Moulinex and then the fried steaks were drained in basket to remove excess oil.

Grilling: Frozen mullet steaks were thawed, rubbed with bran and grilled using electrical grill machine at 260°C for 15 minutes for each side of the steaks. The grilled fish samples were spiced for 1 minute using a special spiced solution containing black pepper, cumin, red pepper and garlic.

Storage studies

Raw mullet fish steaks were packed in polyethylene bags and stored in deep freezer at -18°C for 180 days. Samples were withdrawn periodically at intervals of 60 days for analysis and to prepare the fried and grilled fish steaks.

Physiochemical quality parameters

Total volatile basic-nitrogen (TVB-N): Total volatile basic-nitrogen was determined by macro-distillation method as described by previous study [12] and the results obtained were expressed as mg TVB-N/100 g fresh sample.

Thiobarbituric acid (TBA): Malonaldehyde content was calorimetrically determined as described by previous study [12] and the results were expressed as mg malonaldhye/kg of sample.

pH: The pH value was measured according to previous study [13] as the follows: 10 g of the minced sample were homogenized with 100 ml of distilled water and the mixture was filtered by using filter paper. The pH value of the filtrate was measured using pH meter with combined electrode.

Microbiological analysis

Ten grams of sample were taken aseptically from different places of fish samples and homogenized in 90 ml sterile distilled water (9.0 g NaCl/1000 ml distilled water) as described in previous study [14]. The homogenized samples were used for microbial determination.

Total bacterial count (TBC): Total bacterial count (TBC) was determined by using nutrient agar medium [15]. The standard agar medium was prepared as following:

The media was sterilized by autoclaving at 121°C for 15 min. 1.0 ml from the final dilution was placed on the above medium (15-20 ml) in three replication and incubated at 37°C for 2 days. The bacterial count was calculated per one gram of sample and expressed as mean log cfu/g sample.

Yeasts and molds count: Yeasts and molds count were enumerated on malt agar as mentioned by previous study [16]. Malt agar medium was prepared as following:

Malt extract: 30 g, agar: 15.0 g and distilled water: 1.0 l. The media was sterilized by autoclaving at 121°C for 15 min.

Statistical analysis

The results were analyzed statistically using the least significant difference test (L.S.D) at $(P \leq 0.05)$ and Standard Erorr (Mean ± SE) which calculated using SPSS 16.0 for windows.

Results and Discussion

Physiochemical quality parameters of fresh fish

Total volatile basic nitrogen (TVBN), Thiobarbeturic acid (TBA) and pH are good indexes to determine the freshness and quality of fish and fish products. Data presented in Table 1 show the values of TVBN, TBA and pH values for mullet fish used in the present study. The results indicated that TVBN and TBA contents of mullet fish were 13.25 ± 0.144 mg/100 g and 0.88 ± 0.057 mg malonaldehyde/kg, respectively. Also, pH value was 6.2 ± 0.577. These values of TVBN and TBA and pH indicated the high freshness and good quality of mullet fish used in this work and agreed with previous studies. According to previous study [6] fish is evaluated as 'very good', if the TVB-N value is lower than 25 mg/100 g. Also, a study [17] reported that TBA value should be less than 3.0 mg mgmalonaldeyde/kg in the perfect quality material and a study [18] stated that pH value of fish can be in the range of 5.4 to 7.2, depending on fish species.

Microbiological quality characteristics: The microbial status of seafood after catching is closely related to the environmental conditions and the microbiological quality of the water. The microbiological examination of fresh mullet fish shown in Table 2 indicated that total bacterial count was as low as 3.3 ± 0.144 $\log_{10}$ cfu/g, and also yeast and mould count was as low as 1.94 ± 0.034 $\log_{10}$ cfu/g. These observations revealed

Table 1: *Physiochemical quality parameters of Mullet fish steaks.*

Particular	Value
Total volatile basic nitrogen (mg/100 g)	13.25 ± 0.14
Thiobarbaturic acid (mg malonaldhyde/kg)	0.88 ± 0.057
pH	6.2 ± 0.577
Data are presented as mean ± SE of 3 replicates. SE: Standard Error.	

Table 2: *Microbiological examination of Mullet fish steaks.*

Particular	Log10 cfu/g
Total bacterial count	3.3 ± 0.144
Yeast and molds	1.94 ± 0.034
Data are presented as mean ± SE of 3 replicates. SE: Standard Error.	

the microbiology safety of mullet fish used in the study. A study [19] suggested total bacterial count of $<10^4$ cell/g for fresh fish.

Effect of cooking method on mullet fish steaks immediately after processing: Steaks prepared from mullet fish were cooked by frying and grilling methods by following the normal conditions of such cooking methods. Samples of the fried and grilled steaks were immediately analysed for their physiochemical quality attributes and examined for their microbiological safety.

Total volatile basic nitrogen (TVB-N): Total volatile basic nitrogen (TVB-N) is ageneral term which includes the measurement of trimethylamine (TMA), dimethylamine (DMA), ammonia, and other volatile basic nitrogenous compounds associated with seafood spoilage [20]. Changes in Total Volatile Basic Nitrogen (TVB-N) of mullet fish steaks cooked by frying and grilling are represented in Table 3. The TVB-N of raw, fried and grilled mullet steaks were determined by 13.25 ± 0.144, 12.48 ± 0.277 and12.96 ± 0.554 mg/100 g, respectively.

The highest content of TVB-N (13.25 ± 0.144 mg/100 g) was found in raw mullet steaks and the lowest value (12.48 ± 0.277 mg/100 g) was found in the the fried mullet samples. TVB-N values were slightly decreased after cooking process. This decrease may be due to the effect of hot during frying and grilling that may be resulted in the volatilization and loss of some volatile nitrogen compounds during frying, and also in the grilling process some volatile nitrogen compounds may be dripped and lost in the dipping solution [21]. Similar results were reported by previous study [22] that the TVB-N of raw and cooked Carp fish cutlets were 12.21, 11.75, 11.04 and 11.46 mg/100 g for raw, fried, microwave and halogen cooked samples, respectively.

Thiobarbaturic acid (TBA): TBA is one of the most widely used measurements of seafood quality. TBA value is an important parameter for determining the freshness of fish products. The effects of cooking methods (frying and grilling) on TBA value of mullet fish samples are shown in Table 3. The TBA value of raw, fried and grilled mullet samples were 0.88 ± 0.057, 0.75 ± 0.046 and 0.69 ± 0.034, respectively. TBA values decreased in the cooked samples. The decrease of TBA values in fish samples as affected by cooking methods could be attributed to the interaction of the decomposition products of protein with malonaldehyde to give tertiary products [23] and the formation of secondary products of lipids oxidation, which do not react with the TBA reagent or to the reaction of malonaldhyde with protein [24]. The obtained results go in parallel with those finding by previous study [21].

pH: pH value of fish muscle is usually a good index for quality [25]. The changes in pH value of raw mullet fish and after cooking process are presented in Table 3. The pH value of raw, fried and grilled mullet samples recorded 6.2 ± 0.577, 6.32 ± 0.184 and 6.27 ± 0.155, respectively. The pH value showed slightly increase after cooking process which may be due to the formation of some basic compounds as a result of amino acid degradation [26]. Similar results reported by previous study [21] noticed that the pH values of fresh Tilapia and mullet fish increased in fried and grilled fish products, also observed that the highest pH values recorded for the fried samples followed by grilled and boiled samples, respectively.

Microbiological quality: The total bacterial counts (TBC) of raw and cooked mullet fish samples are presented in Table 4. The obtained results of microbiological aspects of the investigated mullet fish samples are expressed as $\log_{10}$ cfu/g. The results showed a decreasing trend after cooking methods. Total Plate Count (TBC) of raw, fried, grilled samples of mullet fish recorded 3.3 ± 0.144, 2.95 ± 0.040 and 3.04 ± 0.023 (log cfu/g), respectively. Similar observations were also found in the changes of yeast and mould counts of mullet fish samples after cooking process. The results given in Table 4 indicated that the yeast and mold counts were1.94 ± 0.034, 1.3 ± 0.046 and 1.69 ± 0.121 in raw, fried and grilled mullet samples, respectively The lowest yeast and mold counts were observed in the fried samples as compared with raw mullet fish followed by grilled samples. The decreasing in microbiological loads of fish after cooking has been demonstrated for similar other fish types [21,22] and it was attributed to the thermal effect of cooking process in destruction the microorganisms.

Effect of cooking methods on pre-frozen mullet fish steaks at -18±1°C

Quality characteristics of fish products at the time of consumption and eating are greatly depend on several factors including; the freshness and quality of fish, the method and conditions of cooking and the pretreatments and storing or

Table 3: *Physiochemical quality parameters of raw and cooked Mullet fish steaks.*

Parameters	Mullet fish steaks			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
TVB-N(mg/100 g)	13.25 ± 0.14	12.48 ± 0.27	12.96 ± 0.55	0.386	1.03
TBA (mg malonaldhyde/kg)	0.88 ± 0.057	0.75 ± 0.046	0.69 ± 0.034	0.071	0.13
pH	6.20 ± 0.577	6.32 ± 0.184	6.27 ± 0.155	0.973	1.02
Data are presented as mean ± SE of 3 replicates. –SE: standard error. Significant difference at P<0.05.(TVB-N):Total volatile basic nitrogen (mg/100 g) (TBA): Thiobarbaturic acid (mg malonaldhyde/kg).					

Table 4: *Microbiological aspects of raw and cooked Mullet fish steaks.*

Parameters	Mullet fish steaks			Sig.	L.S.D
	Raw Steaks	Fried Steaks	Grilled Steaks		
TBC (log cfu/g)	3.3 ± 0.144	2.95 ± 0.040	3.04 ± 0.02	0.069	0.24
Y and M(log cfu/g)	1.94 ± 0.034	1.30 ± 0.046	1.69 ± 0.12	0.003	0.21
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. Significant difference at P<0.05. TBC: Total Bacterial Count (colony forming unit/g); Y and M: Yeast and Molds					

preservation practices followed before cooking. The present experiments were undertaken to study the storage stability of mullet fish during frozen storage. Mullet fish steak samples were stored at -18°C for 180 days. During storage, samples of fish steaks were withdrew at internals of 60 day. The samples were cooked by two methods; frying and grilling and then analyzed for the chemical quality attributes and microbiological safety.

Physiochemical quality parameters

Total volatile basic nitrogen (TVB-N): Data presented in Table 5 show the changes in total volatile basic nitrogen (TVB-N) contents of raw and cooked mullet fish during frozen storage at -18°C for 180 days. The initial TVB-N contents of raw, fried and grilled mullet fish steaks were determined by 13.25 ± 0.144, 12.48 ± 0.277 and 12.96 ± 0.554 mg/100 g, respectively. During storage, TVB-N contents of raw and cooked mullet fish samples gradually and significantly ($p<0.05$) increased as the storage period extended. The results showed that TVB-N content of raw mullet fish steaks increased to 14.46 ± 0.265, 18.8 ± 0.461 and 26.75 ± 0.433 mg/100 g after 2.0,4.0 and 6.0 months of frozen storage, respectively. After the same periods of storage TVB-N content of the fried samples were 13.66 ± 0.381, 16.2 ± 0.115 and 21.9 ± 0.519 mg/100 g, respectively and the grilled samples contained 14 ± 0.577, 17.56 ± 0.323 and 24.18 ± 0.103 mg/100 g, respectively. These findings indicated that storage time had the pronounced effect in increasing TVB-N contents of the raw and cooked mullet fish steaks and the grilled samples showed higher values of TVB-N in comparison with the fried samples. However, in spite of increasing TVB-N values, it could be concluded that the evaluated raw and cooked mullet fish samples retain their good qualities for about 4.0 to 6.0 months of frozen storage and they were still since their contents of TVB-N did not increased to the values to become rejected or spoiled. This conclusion is supported by studies stated that samples could be considered consumable if the TVB-N level is less than 20 mg/100 g fish and that a level of more than 30 mg/100 g determines the product as not consumable [27,28]. Several studies showed similar behavior regarding increasing TVBN levels in fish products during storage (udersimilar conditions) of some other species of fish such as Mackerel [28,29], Carp fish cutlets [22] and mullet and Tilapia [21]. Increasing TVB-N values during storage was attributed to the activity of microbial and endogenous protolytic enzymes which breakdown proteins to volatile nitrogenous compounds [30-32].

Thiobarbituric acid (TBA): The development of lipid oxidation in the raw and cooked mullet fish samples was studied during 6.0 months of frozen storage and the results obtained are presented in Table 6 in terms of mg malonaldhyde/kg, Initially, TBA values of raw, fried and grilled mullet samples were 0.88 ± 0.0577, 0.75 ± 0.046 and 0.69 ± 0.034 mg malonaldhyde/kg, respectively. During frozen storage of mullet samples, TBA values showed gradual and significant ($P<0.05$) increases. At the end of storage period (180 days), TBA values of raw, fried and grilled mullet samples increased significantly ($P<0.05$) up to 2.44 ± 0.075, 1.95 ± 0.069 and 1.47 ± 0.098 mg malonaldhyde/kg, respectively. These increases in TBA values may be due to the ice crystals formed which could injure the tissues of fish steaks resulting in the release of some pro-oxidants for lipid oxidation especially the free iron [32]. The increasing of TBA value during frozen storage of raw and cooked mullet fish samples has been demonstrated by several investigators for other fish types [21,29,33]. The most important limiting factor in frozen storage of fish especially in fatty species is the oxidation of the lipids stored in muscle tissue. The investigated samples of raw and cooked mullet fish samples showed good quality during 6.0 months of frozen storage.

pH value: pH values of the tested samples of raw and cooked mullet fish steaks were measured and the results obtained are presented in Table 7. Initially, pH values of raw, fried and grilled mullet samples were measured by 6.20 ± 0.577, 6.32 ± 0.184 and 6.27 ± 0.155, respectively. Almost, no considerable changes could be observed in the pH values during frozen storage of raw and cooked mullet fish samples. At the end of 6.0 months storage pH values of raw, fried and grilled mullet fish samples slightly increased to 6.44 ± 0.254, 6.68 ±

Table 5: *Effect of frozen storage at –18C and cooking method on TVB-N (mg/100 g) in Mullet fish steaks.*

Storage time (Months)	TBA (mg malonaldhyde/kg)			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
0	13.25 ± 0.144	12.48 ± 0.277	12.96 ± 0.554	0.368	1.03
2	14.46 ± 0.265	13.66 ± 0.381	14.00 ± 0.577	0.462	1.2
4	18.80 ± 0.461	16.20 ± 0.115	17.56 ± 0.323	0.004	0.939
6	26.75 ± 0.433	21.9 ± 0.519	24.18 ± 0.103	0	1.11
Sig.	0	0	0	-	-
L.S.D	0.991	1	1.22	-	-
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. Significant difference at P<0.05.					

Table 6: *Effect of frozen storage at -18°C and cooking method on TBA (mg malonaldhyde/kg) in Mullet fish steaks.*

Storage time (Months)	TBA (mg malonaldhyde/kg)			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
0	0.88 ± 0.0577	0.75 ± 0.046	0.69 ± 0.034	0.071	0.136
2	1.30 ± 0.051	1.2 ± 0.040	1.05 ± 0.028	0.015	0.115
4	1.95 ± 0.086	1.6 ± 0.115	1.22 ± 0.127	0.01	0.314
6	2.44 ± 0.075	1.95 ± 0.069	1.47 ± 0.098	0	0.013
Sig.	0	0	0.001	-	-
L.S.D	0.193	0.206	0.236	-	-
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. Significant difference at P<0.05.					

0.392 and 6.5 ± 0.230, respectively. These data indicated that raw mullet retained their good qualities during frozen storage up to 6.0 months. Several studies showed increasing pH value in various fish species during frozen storage; [21] on Tilapia and mullet fish, [34] on Tilapia fillets, [35] Sea bass and [36] on Tilapia fish.

Microbiological quality

Fish in general is usually spoil more rapidly than other muscle foods and such spoilage is primarily bacterial in nature. Therefore, good preservation techniques must prevent the microbial spoilage of fish without affecting its quality and nutritional value, [21,37]. The raw and cooked mullet fish steaks were examined microbiologically for the total bacterial count and yeast and mold counts at intervals of 2.0 months during frozen storage at -18°C to assess the microbiological safety of the products.

Total bacterial count (TBC): Data given in Table 8 show the total bacterial count (TBC) of raw mullet fish samples as affected by frozen storage period at -18°C and cooking methods. The results showed that the initial bacterial load of raw mullet fish steaks accounted by 3.3 ± 0.144 $\log_{10}$ cfu/g. Due to cooking effect, the initial bacterial loads of fried and grilled samples were reduced to 2.95 ± 0.040 and 3.04 ± 0.023 $\log_{10}$ cfu/g, respectively. During the frozen storage, it was observed that the values of TBC showed wavy progress for both raw mullet fish and cooked samples. TBC values in raw, fried and grilled samples showed upward trends up to 4.06 ± 0.034, 3.71 ± 0.121 and 3.86 ± 0.089 $\log_{10}$ cfu/g, respectively until 4.0 months followed by downward to the values of 3.92 ± 0.046, 3.11 ± 0.063 and 3.34 ± 0.138 $\log_{10}$ cfu/g, respectively at the end of 6.0 months storage.

The increase of TBC may be due to the multiplication of microbial counts that can able to grow under freezing conditions [38] while the reduction in TBC may be due to the damage of bacterial cells caused by grown ice crystals [39]. A study [40] reported that freezing generally causes a reduction in bacterial count and the number will continue, in most cases, to fall during frozen storage. These results in harmony with [21,22,41,42].

Yeast and molds (Y and M): Data given in Table 9 show mold and yeast counts in raw and cooked mullet fish samples during frozen storage. The initial counts of mold and yeast were 1.94 ± 0.034, 1.3 ± 0.046 and 1.69 ± 0.121 $\log_{10}$ cfu/g for raw, fried and grilled samples at zero time storage. Over the entire period of 180 days of storage, the microbiological analysis showed no detection of mold and yeast in the fried and grilled mullet fish samples could be found expect in the raw sample after 2.0 months. Similarly, previous studies [42,43] found no growth of microorganisms during frozen storage of some fish products at temperature below -18°C.

Conclusion

Cooking methods had a clear effect on the chemical quality

Table 7: *Effect of frozen storage at –18˚C and cooking method on pH value in Mullet fish steaks.*

Storage time (Months)	pH value			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
0	6.20 ± 0.577	6.32 ± 0.184	6.27 ± 0.155	0.973	1.02
2	6.22 ± 0.063	6.38 ± 0.219	6.30 ± 0.202	0.819	0.497
4	6.27 ± 0.733	6.41 ± 0.236	6.37 ± 0.213	0.976	1.3
6	6.44 ± 0.254	6.68 ± 0.392	6.50 ± 0.230	0.846	0.851
Sig.	0.984	0.792	0.856	-	-
L.S.D	1.37	0.764	0.572	-	-
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. -Significant Difference at P<0.05.					

Table 8: ***E****ffect of frozen storage at – 18°C and cooking method on total bacterial count (TBC) log cfu/g in Mullet fish steaks.*

Storage time (Months)	TBC ($\log_{10}$ cfu/g)			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
0	3.3 ± 0.144	2.95 ± 0.040	3.04 ± 0.023	0.069	0.247
2	4.15 ± 0.086	3.6 ± 0.115	3.77 ± 0.051	0.05	0.252
4	4.06 ± 0.034	3.71 ± 0.121	3.86 ± 0.089	0.083	0.252
6	3.92 ± 0.046	3.11 ± 0.063	3.34 ± 0.138	0.002	0.258
Sig.	0.001	0.001	0.001	-	-
L.S.D	0.252	0.258	0.247	-	-
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. Significant difference at P<0.05.					

Table 9: *Effect of frozen storage at –18˚C and cooking method on yeast and mold log cfu/g in Mullet fish steaks.*

Storage time (Months)	Yeast and Mold count ($\log_{10}$ cfu/g)			Sig.	L.S.D
	Raw steaks	Fried steaks	Grilled steaks		
0	1.94 ± 0.034	1.3 ± 0.046	1.69 ± 0.121	0.003	0.219
2	1.17 ± 0.098	ND	ND	0	0.163
4	ND	ND	ND	-	
6	ND	ND	ND	-	
Sig.	0	0	0	-	-
L.S.D	0.146	0.073	0.171	-	-
Data are presented as mean ± SE of 3 replicates. SE: Standard Error. Significant difference at P<0.05. ND: Not Detect.					

parameters as they reduced it except the pH value. For microbial quality, the decrease in microbial load was the most pronounced reduction in fried mullet fish steaks than grilled. During the freezing period, the values of the chemical and microbiological quality indices increased until the end of the storage period but were within the permissible limits.

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