

Changes in Sensory and Microbiological Quality Indices of Nile Tilapia (*Oreochromis niloticus*) and Grey Mullet (*Mugil cephalus*) During Ice Storage

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ABSTRACT

This study was carried out to determine quality changes of Nile tilapia (*Oreochromis niloticus*) and grey mullet (*Mugil cephalus*) stored in ice. Changes in sensory and microbiological attributes were evaluated during 16 and 14 day of storage for Nile tilapia and grey mullet, respectively. The overall sensory scores of both raw and steamed Nile tilapia and grey mullet gradually decreased with the ice storage. Highly significant correlation was found between the overall sensory scores of both raw and steam cooked Nile tilapia and grey mullet and storage time. The shelf life of Nile tilapia and grey mullet were 8 days in ice. The mesophilic aerobic bacterial count of Nile tilapia and flathead grey mullet flesh increased gradually during storage in ice from 2.38×10^3 and 7.67×10^2 CFU/g flesh to 4.10×10^4 and 2.13×10^4 CFU/g flesh after eight day of ice storage. The psychrophilic aerobic bacterial count increased gradually during storage in ice from 5.97×10^2 and 4.76×10^3 CFU/g flesh to 6.30×10^4 and 1.66×10^5 CFU/g flesh after eight day of ice storage. Psychrophiles had faster rate of increment during storage in ice, compared to mesophiles. Based on results of sensory evaluation the iced raw and steamed Nile tilapia and grey mullet samples could be classified into three categories of quality grade as follows : (1) high quality grade (stored in ice for not more than 4 days) (2) acceptable grade (stored in ice for more than 4 days, but less than 8 days), (3) unacceptable grade (stored in ice for more than 8 days).

Key words:- Sensory evaluation, Bacteriological evaluation, Nile tilapia, Grey mullet, Ice storage, Quality.

INTRODUCTION

Nowadays, there is an increasing demand for fish as an important source of food around the world (Silva *et al.*, 2011). The share of fisheries production used for direct human consumption increased from about 70 % in the 1980s to more than 85 % in 2012 (FAO, 2014). Egypt has one of the world's largest aquaculture sectors which makes a significant contribution to income, employment creation and food security. Animal foods provide important sources of energy, micro and macro nutrients but are commonly associated with food borne diseases. Livestock and fish value chains support the livelihoods of millions of rural and urban poor, for whom they can act as pathways out of poverty (ILRI, 2011).

The Nile tilapia, *Oreochromis niloticus* Linnaeus (Pisces: Cichlidae) is one of the most important fish

species in the inland fisheries of tropical Africa, particularly in the Great East African rift valley lakes. Besides to its captured fisheries importance, Tilapia is one of the most important species for 21st century aquaculture and is produced in more than 100 countries. Tilapias are now the second most popular farmed fishes after carps in the world (El-Sayed, 2006, Eknath *et al.*, 2007, Yitayew, 2012 and moawad *et al.*, 2017). The global production of farmed tilapia exceeded 2,002,087 metric ton (Yitayew, 2012). The average size (total length) of *O. niloticus* is 20 cm (FAO, 2012).

The most important producers of tilapia today are China, Egypt, Indonesia, and Philippines. The advantages of tilapia are its rapid growth, resistance to various diseases and stress, tolerance to changing environmental conditions, and willingness to spawn in captivity (Shoemaker *et al.*, 2000). Illustrations from Egyptian tombs suggest that Nile tilapia were cultured more than 3,000 years ago (Popma and Masser, 1999).

Mullets are members of the Order Mugiliformes, Family Mugilidae. Mullets are ray-finned fish found worldwide in coastal temperate and tropical waters and, some species, in freshwater. Most species commonly reach about 20 cm total length, but some (e.g. *Mugil cephalus*) may attain 80–120 cm. The head is broad and flattened dorsally in most species. The flathead grey mullet, *Mugil cephalus*, is a very important aquaculture species in the Mediterranean, Southeast Asia, Taiwan, Province of China, Japan and Hawaii (Saleh, 2008). Mullets are an important component of Egyptian fisheries and are considered as one of the most important cash crops from artisanal fisheries in the numerous lagoons throughout the country. The fish is commonly caught with gill, trammel and veranda nets by artisanal fishers operating in the sea, lakes and coastal lagoons (Saleh, 2008).

Iced storage is an important preservation method to maintain the quality and freshness of fish during handling and storage. Icing has been used widely to reduce undesirable biochemical and chemical reactions and to retard the growth of spoilage and pathogenic microorganisms. It is the cheapest and the most common

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and efficient preservative method utilized worldwide (Madrid and Philips, 2000).

Ice storage constitutes the first step, or at times, the only means of preserving fresh fish in Egypt in order to prevent and retard the lowering of freshness due to degradation of muscle protein which is a major reaction of the spoilage process in fish (Saltana, 2004). Efficient cooling with ice depends on the weight of fish, species, fish temperature, environmental temperature and the amount of ice (Bataranganya, 2007). Even during cold storage, whether using ice or refrigeration, the growth of spoilage microorganisms, and the chemical and enzymatic activity although slower, will over time lead to fish quality being diminished (Cakli *et al.*, 2007). The shelf life of fish shelf life can be determined by physicochemical and microbiological analysis, as well as, sensory changes that occur in fish during the storage period have been commonly used (Massa *et al.*, 2012, Borges *et al.*, 2013 and Giuffrida *et al.*, 2013).

Sensory assessment is the best way to evaluate the freshness and shelf life of fish as it is understandable by consumers and is indispensable for marketing (Joseph and Iyer, 2002) and (Sallam *et al.*, 2007). However, sensory methods in general are known to be irrationally expensive due to the high training requirement of the panel; cost of running, need for individual scheme for individual fish species given the different spoilage patterns and physiological and psychological limitations of the analyst (Connell, 2001).

The major changes in fish freshness colour are largely due to bacterial activity. Microbiological methods are used to the freshness of fish, hygiene to detect presence of bacteria or organisms of public health importance (Dalgaard, 2002).

There are many factors affecting the initial microbial load and the storage time of food such as fish species, bacterial load, water temperature catching method, handling and storage conditions (Andrade *et al.*, 2012, Chong *et al.*, 2012 and Carracosa *et al.*, 2014). The activity of microorganisms is the main factor limiting the shelf life of fresh fish. An estimation of the total viable counts (TVC) is used as an acceptability index in standards, guidelines and specifications (Olafsdottir *et al.*, 1997).

There are little information regarding the storage life of Nile tilapia and grey mullet stored in ice in Egypt. Therefore, the present study was under taken to assessment shelf life and freshness of Nile tilapia and grey mullet during storage in ice at ambient temperature.

MATERIALS AND METHODS

Materials:-

The fresh Nile tilapia (Bolti) (*Oreochromis niloticus*) and grey mullet (Bouri) (*Mugil cephalus*) are utilized in the present study during 2015.

15 kg of Nile tilapia (*Oreochromis niloticus*) were obtained from EL-Nozha Airport farm, Alexandria, while 15 kg of grey mullet (*Mugil cephalus*) were obtained from a private farm, Edkou, EL- Behera Governorate.

Fish samples were immediately transferred to the laboratory in the insulated boxes contained crushed ice for analysis (zero time). Nile tilapia had an average weight and length of 243.37 g and 21.03 cm, while mullet had 309.8 g and 31.32 cm, respectively.

Fish samples were mixed with crushed ice in layers form plastic containers of 1:2 (w/w) ratio. The plastic containers had holes at their bottoms for drainage the melted ice. The containers were held at an ambient temperature ($21 \pm 2^{\circ}\text{C}$). The fish samples were kept always covered with crushed ice during ice storage period by adding fresh ice to maintain the above mentioned ratio. Meanwhile, samples of fish were withdrawn at regular intervals (2, 4, 6, 8, 10, 12, 14 and 16 days of ice storage) for sensory and microbiological evaluation.

Methods:-

1. Sensory evaluation

Sensory evaluation of raw tilapia and mullet was performed by ten trained panelists chosen from the staff members of the Department of Food Science and Technology, Faculty of Agriculture, Alexandria University. The organoleptic assessment of raw tilapia and mullet were made according to the scale described by Barile *et al.* (1985). This scale ranged from zero (extremely unacceptable) to 10 (highly acceptable) for the following characteristics: acceptability, eye pupil, gills, body surface (appearance), odour, texture, flesh condition, viscera and belly wall.

Sensory evaluation of cooked tilapia and mullet samples was applied on 100g flesh after steaming in lidded aluminum pan for 10 min. The panelists were asked to score the organoleptic properties of the sample by giving scores ranged between 0 to 10 as described by Barile *et al.* (1985).

2. Bacteriological analysis

10 g of flesh are transferred into 90 ml 0.1% peptone water. From this dilution, other decimal dilutions were prepared. Total psychrophilic and mesophilic aerobic plate count were determined by the pour plating technique, using plate count agar (PCA) and the plates

were inverted and incubated in an incubator at 35°C for 48 h for mesophilic bacteria and at 7-10°C for 10 days for psychrophilic bacteria (Bahmani *et al.*, 2011).

Finally the number of colonies were counted and multiplied by dilution factor to calculate the total colonies forming units per g sample (Abelti, 2013).

3. Statistical analysis

Analysis of variance, regression and correlation were carried out according to Gomez and Gomez (1984) using SAS (Statistical Analysis System) ver.9.1, 2000.

RERSULTS AND DISCUSSION

1. Sensory evaluation:

1. 1. Sensory evaluation of Nile tilapia

The data obtained from sensory evaluation of raw and steamed Nile tilapia (*Oreochromis niloticus*) during storage in ice at ambient temperature are presented in Table (1) and Fig. (1). The values were calculated as means of ten scoring evaluations during storage in ice.

There was a marked reduction in the sensory properties during ice storage. Storage of tilapia in ice usually concomitant with great changes in the appearance of raw Nile tilapia (Fig. 1). Body surface of fresh Nile tilapia was found to have a bright shining greenish blue colour immediately after catch, which progressively changed to a dull and slight grey when samples were attained the border of unacceptability. The colour of gills changed from bright red to pale dark red colour for the unacceptable samples. During storage of tilapia in ice, eyes appeared to progressively less crystalline and sunken. Flesh of tilapia, which was initially firm, became slightly soft on the unacceptability and at the end of the storage period, it converted into pasty and became easily separated from the bones. Belly wall was found to be bright firm and gradually changed to dull and digested as the time of storage proceeded.

Sensory panel score for odour, taste and texture of iced storage tilapia and after cooking in steam are presented in Table (1). The data indicated that the storage of Nile tilapia in ice had a noticeable effect on the reduction of taste scores, followed by the texture and odour of steamed cooked samples.

Results of sensory evaluation, as overall quality of raw and steamed Nile tilapia during storage in ice, are presented in Fig. (1). Fresh Nile tilapia taken immediately after catch possessed higher overall sensory scores ranged from 9 to 10 (out of 10) for both raw and steamed samples. Such scores decreased gradually with increasing the time of storage in ice. The results obtained in the present study are in a good agreement with those reported by Yasmine *et al.* (2001), Partiban *et al.* (2005), Adoga *et al.* (2010), Liu *et al.* (2010),

Farag (2012), Reshika *et al.* (2013), Kapute *et al.* (2013), Abraham-Olukayode and Oramadike (2015) Goliat *et al.* (2016) and Rodrigues *et al.* (2016).

The shelf life of Nile tilapia stored in ice at ambient temperature was limited on the basis of the overall sensory scores as shown in Fig. (1). The overall sensory scores less than 5 points meant that Nile tilapia samples was organoleptically rejected. According to the overall sensory scores (Table 1 and Fig.1), the raw and steamed samples during storage in ice could be classified into three categories of quality grade as follows : (1) high quality grade (stored in ice for not more than 4 days) (2) acceptable grade (stored in ice for more than 4 days, but less than 8days) and (3) unacceptable grade (stored in ice for more than 8 days).

Based on sensory evaluation, Nile tilapia still acceptable for 8 days in ice storage at ambient temperature, where it became rejected after elapsing 8 days of storage in ice (Table 1).

The results obtained in the present study are in a general agreement with those of Partiban *et al.* (2005), Liu *et al.* (2010) and Farag (2012).

According to the results obtained by Yasmine *et al.* (2001) , Adoga *et al.* (2010), Kapute *et al.* (2013) , Abraham-Olukayode and Oramadike (2015) Goliat *et al.* (2016) and Rodrigues *et al.* (2016) the shelf life of tilapia were higher than those found in the present study. On the other hand, Reshika *et al.* (2013) stated that shelf life of Nile tilapia stored in ice ranged between 3-5 days.

The longer shelf life of fresh fish stored in ice could be attributed to the low temperature resulted from ice that hinders microbial growth (Uchoi *et al.*, 2011).

The acceptable storage life of each species is affected by many factors including, the catching method, the location of the fishing ground, the season of the year, the size of the fish, etc, (Lima dos Santos, 1981 and Andrade *et al.*, 2015).

1. 2. Sensory evaluation of grey mullet

Table (2) shows the sensory evaluation of raw and steamed grey mullet (*Mugil cephalus*) during ice storage at ambient temperature. The initial quality characteristics of raw flathead grey mullet were very high as it were, very bright appearance, elastic texture, bright and convex eyes and fresh odours.

The organoleptic scores decreased and the rejection of fish increased gradually with the time elapsed of storage (Fig. 2). The results obtained in the present study are in a good agreement with those reported by Özyurt *et al.* (2009), Bahmani *et al.* (2011) Reshika *et al.* (2013), Ninan and Zynudheen (2014) and Andrade *et al.* (2015).

Table 1. Changes in sensory evaluation* of raw and steamed Nile tilapia during storage in ice at ambient temperature**

Sensory quality parameter	Storage in ice (days)																I. S. D.
	0	2	4	6	8	10	12	14	16	16	16	16	16	16	16	16	
Raw tilapia																	
Eye	9.80 ^a ±0.63	9.20 ^b ±1.03	7.80 ^b ±0.44	7.20 ^b ±0.63	5.80 ^c ±0.63	4.80 ^d ±1.40	3.90 ^e ±0.32	2.20 ^f ±0.52	1.00 ^g ±1.32	0.63							
Gills	9.50 ^a ±0.97	8.90 ^{ab} ±0.32	8.70 ^b ±1.16	7.70 ^c ±0.48	6.80 ^d ±0.42	4.80 ^e ±1.29	4.10 ^f ±0.74	2.20 ^g ±0.42	0.60 ^h ±1.33	0.64							
Body surface	9.60 ^a ±0.84	8.30 ^b ±1.16	8.00 ^b ±1.63	7.80 ^b ±0.42	5.80 ^c ±0.63	4.80 ^d ±1.03	4.20 ^e ±0.79	2.50 ^f ±0.42	1.00 ^g ±0.97	0.87							
Odour	9.70 ^a ±0.95	9.20 ^{ab} ±1.03	8.50 ^b ±1.65	7.60 ^c ±0.70	5.60 ^d ±0.70	4.70 ^e ±1.25	4.30 ^f ±0.67	2.30 ^g ±0.53	0.70 ^h ±1.33	0.87							
Texture	9.70 ^a ±0.48	9.30 ^{ab} ±0.95	8.90 ^b ±1.45	7.80 ^c ±0.42	5.60 ^d ±0.70	4.80 ^e ±0.63	4.00 ^f ±0.47	2.00 ^g ±0.48	0.70 ^h ±1.16	0.65							
Flesh condition	9.60 ^a ±0.82	8.60 ^b ±0.97	8.30 ^b ±1.95	7.70 ^c ±0.48	5.90 ^d ±0.99	4.60 ^e ±0.52	4.10 ^f ±0.32	2.20 ^g ±0.47	0.90 ^h ±0.48	0.82							
Viscera	9.90 ^a ±0.32	9.50 ^{ab} ±0.85	8.30 ^b ±0.95	7.30 ^c ±0.82	5.80 ^d ±0.42	4.50 ^e ±0.85	3.80 ^f ±0.42	2.30 ^g ±0.42	0.80 ^h ±1.29	0.63							
Belly wall	9.80 ^a ±0.63	8.60 ^b ±1.35	8.40 ^b ±1.25	7.60 ^c ±0.79	5.30 ^d ±0.82	4.70 ^e ±0.82	3.80 ^f ±0.42	2.20 ^g ±0.48	1.00 ^h ±1.03	0.78							
Overall acceptability	10.00 ^a ±0.00	9.00 ^b ±1.44	7.80 ^c ±0.42	7.20 ^c ±0.52	5.90 ^d ±0.88	4.90 ^e ±0.88	4.00 ^f ±0.47	2.40 ^g ±0.42	0.80 ^h ±1.33	0.71							
Steamed tilapia																	
Odour	9.80 ^a ±0.63	8.90 ^b ±1.37	8.60 ^b ±0.52	8.00 ^c ±0.47	6.70 ^d ±0.48	5.50 ^e ±1.03	4.90 ^f ±0.87	2.80 ^g ±0.93	1.80 ^h ±0.97	0.76							
Texture	9.40 ^a ±0.70	9.10 ^{ab} ±0.88	8.70 ^b ±1.25	8.30 ^b ±0.48	6.30 ^c ±0.63	5.60 ^d ±0.81	4.20 ^e ±1.48	2.80 ^f ±1.03	1.80 ^g ±1.14	0.81							
Taste	9.50 ^a ±1.08	8.80 ^{ab} ±1.03	8.50 ^b ±0.97	7.50 ^c ±0.60	6.00 ^d ±0.57	5.50 ^e ±0.84	4.50 ^f ±0.71	3.00 ^g ±0.94	1.70 ^h ±1.14	0.82							
Overall acceptability	9.60 ^a ±0.84	8.80 ^b ±1.03	8.60 ^b ±1.08	8.00 ^c ±0.53	6.10 ^d ±0.67	5.20 ^e ±0.81	4.90 ^f ±0.88	3.40 ^g ±0.97	1.40 ^h ±0.95	0.75							

*High grade: stored in ice for not more than 4 days, and overall sensory scores between 10 and 8.
 Acceptable grade: stored in ice for not more than 8days, and overall sensory scores less than 8 and more than 5.
 Unacceptable grade: stored in ice for 8days or more, and overall sensory scores 5 or less.
 **Data as mean ± SD.
 Means in the same row sharing the same letters are not significantly different, at P< 0.05 level.

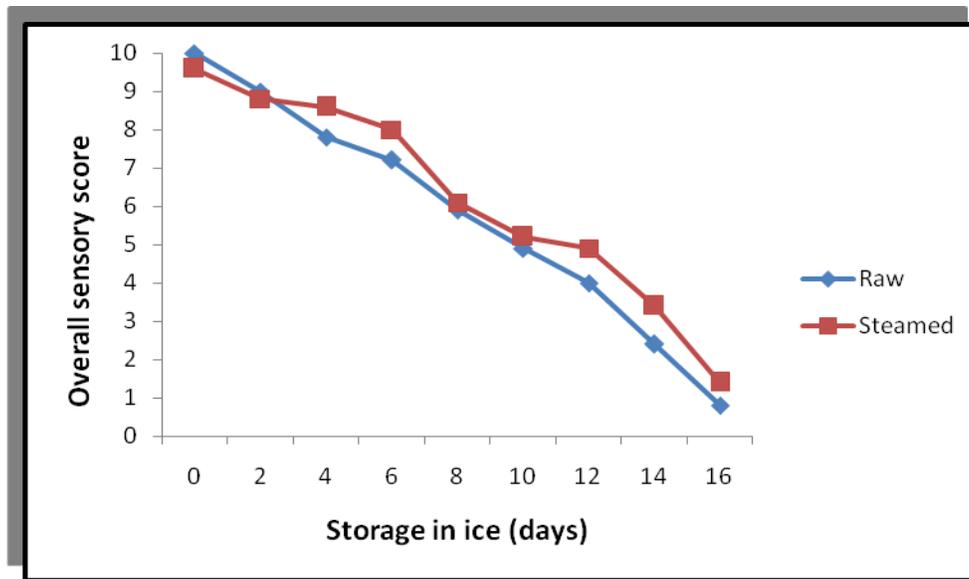


Fig. 1. Changes in sensory evaluation of raw and steamed Nile tilapia during storage in ice at ambient temperature

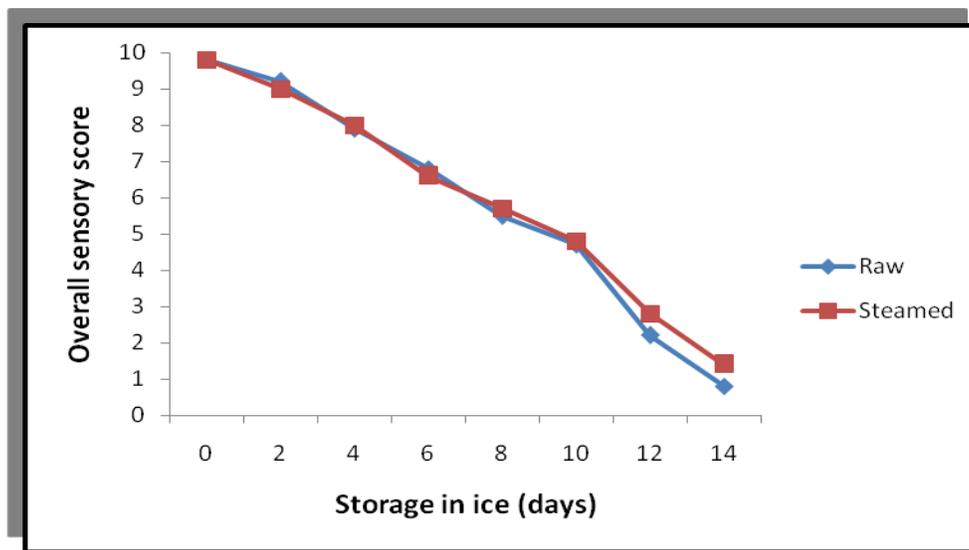


Fig. 2. Changes in sensory evaluation of raw and steamed flathead grey mullet during storage in ice at ambient temperature

The decrement of sensory scores was highly correlated with storage time Fig. (2), indicating quality deterioration. Fresh seaweedy odour, bright red firm texture and no-off odours were observed in fresh raw mullet as well as intense sweetness and meaty flavour were tasted in steamed samples.

Raw fish still in good quality and acceptable within 4-8 days of storage, after that, the quality was deteriorated.

The normal colour of the fresh fish may changed during storage and discolouration may occurred. The pigments may have been oxidized or affected by some

other factors. It is known that lipids convert to peroxides, aldehydes, ketones and lower aliphatic acids when they are oxidized (Sowicz *et al.*, 2004). Although hydroperoxides are tasteless, they can brown and yellow colours in the fish tissue and gills (Bataringanya, 2007). Some browning also occurs in fatty fishes due to hydrolytic form reactions of fats and proteins (MANAGE, 2000).

As a result of prolong storage the texture of the muscle became more softer, eyes lose its concavity and scales became less adhered with the skin (Uchoi *et al.*, 2011).

Table 2. Changes in sensory evaluation* of raw and steamed flathead grey mullet during storage in ice at ambient temperature**

Sensory quality parameters	Storage in ice (days)														L. S. D.			
	0	2	4	6	8	10	12	14	14	14	14	14	14	14				
Raw mullet																		
Eye	9.80 ^a ±0.63	9.00 ^b ±1.03	8.20 ^c ±0.63	6.50 ^d ±0.53	5.90 ^d ±0.97	4.20 ^e ±0.67	2.10 ^f ±1.66	0.80 ^g ±1.03	0.74									
Gills	9.60 ^a ±0.42	9.20 ^b ±0.67	8.00 ^b ±0.92	6.20 ^c ±1.23	5.20 ^d ±0.74	4.30 ^e ±1.48	2.40 ^f ±0.32	0.80 ^g ±1.41	0.89									
Body surface	9.60 ^a ±0.52	9.00 ^b ±0.42	7.60 ^b ±1.05	6.90 ^b ±1.44	5.70 ^c ±1.32	4.40 ^d ±1.16	2.30 ^e ±0.84	0.80 ^f ±1.03	0.91									
Odour	9.80 ^a ±0.84	9.00 ^b ±1.03	7.90 ^c ±0.84	6.90 ^d ±0.74	5.60 ^e ±0.82	4.70 ^f ±1.26	2.20 ^g ±0.48	0.60 ^h ±1.03	0.72									
Texture	9.90 ^a ±0.63	9.40 ^b ±1.05	7.40 ^b ±0.32	6.20 ^c ±1.03	5.60 ^c ±0.97	4.10 ^d ±0.95	2.20 ^e ±0.42	0.60 ^f ±0.97	0.81									
Flesh condition	9.80 ^a ±0.32	9.00 ^b ±0.70	7.60 ^c ±1.08	6.80 ^d ±1.03	5.60 ^e ±0.97	4.40 ^f ±0.88	2.20 ^g ±1.03	0.80 ^h ±1.08	0.78									
Viscera	9.90 ^a ±0.63	9.20 ^b ±1.05	8.00 ^b ±0.84	6.90 ^c ±0.88	5.80 ^d ±0.70	4.20 ^e ±0.70	2.40 ^f ±0.63	0.80 ^g ±1.03	0.87									
Belly wall	9.80 ^a ±0.32	9.20 ^b ±0.63	7.80 ^b ±0.82	6.80 ^c ±1.03	5.40 ^d ±1.14	4.00 ^e ±1.55	2.20 ^f ±0.97	0.80 ^g ±1.23	0.84									
Overall acceptability	9.80 ^a ±0.63	9.20 ^b ±1.03	7.90 ^b ±0.63	6.80 ^c ±1.20	5.50 ^d ±0.97	4.70 ^e ±1.33	2.20 ^f ±0.42	0.80 ^g ±1.03	0.74									
Steamed mullet																		
Odour	9.80 ^a ±0.63	9.10 ^b ±1.05	8.50 ^b ±0.53	6.80 ^c ±0.63	5.70 ^d ±0.95	4.60 ^e ±0.82	2.20 ^f ±0.97	1.60 ^g ±0.97	0.65									
Texture	9.90 ^a ±0.42	9.00 ^b ±0.74	8.50 ^b ±0.52	6.80 ^c ±1.03	5.80 ^d ±0.42	4.60 ^e ±0.92	2.40 ^f ±0.63	1.20 ^g ±1.58	0.72									
Taste	9.70 ^a ±0.32	8.80 ^b ±0.82	8.00 ^c ±0.00	6.50 ^d ±0.52	5.60 ^e ±0.52	4.70 ^f ±0.97	2.60 ^g ±0.84	1.20 ^h ±1.97	0.73									
Overall acceptability	9.80 ^a ±0.95	9.00 ^b ±1.03	8.00 ^c ±0.00	6.60 ^d ±0.97	5.70 ^e ±0.67	4.80 ^f ±0.97	2.80 ^g ±1.03	1.40 ^h ±1.03	0.78									

High grade: stored in ice for not more than 4 days, and overall sensory scores between 10 and 8.
 Acceptable grade: stored in ice for not more than 8days, and overall sensory scores less than 8 and more than 5.
 Unacceptable grade: stored in ice for 8days or more, and overall sensory scores 5 or less.
 *Data as mean ± SD.
 **Means in the same row sharing the same letters are not significantly different, at P< 0.05 level.

Similarly, all sensory characteristics of steamed samples (Table 2) had higher scores before 8 days, decreased gradually and became unacceptable on day 10 (Table 2).

The limit of acceptability for mullet was observed after 8 days while the lowest score was observed on day 14. This finding was close to the values reported by Özyurt *et al.* (2009), Bahmani *et al.* (2011) and Reshika *et al.* (2013).

On the other hand, the results of shelf life in the present study are in agreement with those reported by Ninan and Zynudheen (2014) and Andrade *et al.* (2015).

2. Bacteriological evaluation:

2. 1. Mesophilic and psychrophilic aerobic bacterial count of Nile tilapia

The data presented in Table (3) show the changes in mesophilic and psychrophilic aerobic bacterial count (CFU/g flesh) of Nile tilapia (*Oreochromis niloticus*) during storage in ice at ambient temperature.

The increasing rate of mesophilic count was slower during the first 2 days of storage in ice, it was less than one logarithmic cycle, thereafter increased regularly till the end of storage period. There was significant difference ($P < 0.05$) between fresh samples (zero time) and iced storage samples (Table 3).

The mesophilic count increased gradually during ice storage from 2.38×10^3 CFU/g flesh at zero time to 4.10×10^4 CFU/g flesh at the eighth day of iced storage, where the samples organoleptically rejected (Table 3).

As it can be seen from Table (3), the pattern of changes in psychrophilic bacterial count in Nile tilapia flesh was similar as in mesophilic bacterial count. The psychrophilic bacterial count tended to gradually increase throughout the iced storage period. The initial level of psychrophiles (zero time) was 5.97×10^2 CFU/g flesh and increased during iced storage up to 6.30×10^4 CFU/g flesh after 8 days of storage, where the samples were unacceptable.

The results of the present study are in accordance with those reported by Huss *et al.* (1997), Yasmin *et al.* (2001), Adoga (2010), Liu *et al.* (2010), Kulawik *et al.* (2013) Castillo-Yanez *et al.* (2014) and Rodrigues *et al.* (2016). They reported that the bacterial count of Nile tilapia flesh varied from 10^2 - 10^3 CFU/g flesh and increased during storage in ice up to 10^6 in the rejected samples.

The present results are not in accordance with those obtained by Abelti (2013) who reported that bacterial

count was ranged from 6.33 CFU/g on day zero and 11.74 CFU/g on day 26 of storage in ice.

Variation in the initial bacterial load could be ascribed to the microbial load of the waters in which they live (Huss, 1988). The eventual increase observed in mean total plate count could be due to multiplication of organisms favored at the storage condition (Ibrahim and El -Sherif, 2008).

High significant correlation coefficient was found between mesophilic bacterial count and sensory evaluation ($R^2 = -0.82$) during iced storage period, which not observed in psychrophilic bacteria ($R^2 = -0.62$).

A significant positive regression coefficient was obtained between storage days and mesophilic bacterial count in Nile tilapia samples ($R^2 = +0.59$) (Fig. 3), which not observed in psychrophilic bacteria ($R^2 = +0.30$) (Fig. 4).

The present study indicated that the initial psychrophilic bacterial count of fresh Nile tilapia at zero time (5.97×10^2 CFU/g flesh) was lower than that of mesophilic bacterial count (2.38×10^3 CFU/g flesh) by one logarithmic cycle (Table 3). Although the increase in psychrophilic bacterial count was parallel to the increase in mesophilic bacterial count, but the increasing rate of the psychrophiles faster during the iced storage period. These results agreed with the results reported by Liu *et al.* (2010). Therefore, the rejection levels of both in mesophilic and psychrophilic aerobic bacterial count at the eighth day of storage in ice were closely the same 4.10×10^4 and 6.30×10^4 CFU/g flesh, respectively.

The mesophilic and psychrophilic aerobic bacterial count of Nile tilapia samples at the eighth day of storage in ice, when Nile tilapia was unacceptable according to sensory evaluation (4.10×10^4 and 6.30×10^4 CFU/g flesh, respectively). This level agreed greatly with the recommendations set by ICMSF (1986), IFST (1999) and EOS (2005) which claimed that the maximum bacterial limit for fresh never exceeds the 10^6 CFU/g flesh.

It could be concluded that the initial load of mesophilic bacteria was tenfold psychrophilic bacterial load. The mesophilic bacteria were easily adapted to growth at iced storage temperature, also, the psychrophilic bacteria had faster increasing rate during the iced storage compared with mesophiles. The above mentioned results may help in explaining the shorter shelf life of the examined tilapia samples. This conclusion agreed well with what was previously reported by Liu *et al.* (2010).

Table 3. Changes in mesophilic and psychrophilic aerobic bacterial count (CFU* / g flesh) of Nile tilapia during storage in ice at ambient temperature**

Storage in ice (days)	Mesophilic	Psychrophilic
0	$2.38 \times 10^3 \pm 8.04 \times 10^2$	$5.97 \times 10^2 \pm 1.16 \times 10^2$
2	$5.72 \times 10^3 \pm 8.00 \times 10^2$	$1.72 \times 10^3 \pm 3.70 \times 10^2$
4	$1.16 \times 10^4 \pm 1.39 \times 10^3$	$3.10 \times 10^3 \pm 7.21 \times 10^2$
6	$2.43 \times 10^4 \pm 5.03 \times 10^3$	$2.54 \times 10^4 \pm 5.73 \times 10^3$
8***	$4.10 \times 10^4 \pm 7.21 \times 10^3$	$6.30 \times 10^4 \pm 1.20 \times 10^4$
10	$5.83 \times 10^4 \pm 6.03 \times 10^3$	$2.00 \times 10^5 \pm 2.22 \times 10^4$
12	$8.37 \times 10^4 \pm 7.78 \times 10^3$	$6.29 \times 10^5 \pm 1.22 \times 10^5$
14	$2.60 \times 10^5 \pm 6.24 \times 10^4$	$1.68 \times 10^6 \pm 9.43 \times 10^5$
16	$6.23 \times 10^5 \pm 1.38 \times 10^5$	$3.00 \times 10^8 \pm 0.00$
L. S. D.	9.08×10^4	5.38×10^5

*CFU Colony forming unit.

**Data as mean \pm SD.

*** Organoleptically unacceptable samples.

Means in the same column sharing the same letters are not significantly different at $P < 0.05$ level

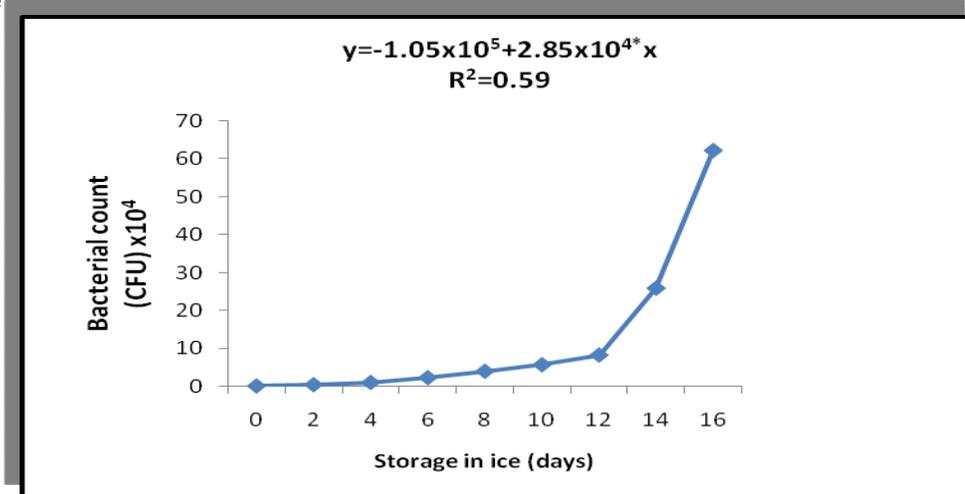


Fig. 3. Changes in mesophilic aerobic bacterial count (CFU / g flesh) of Nile tilapia during storage in ice at ambient temperature

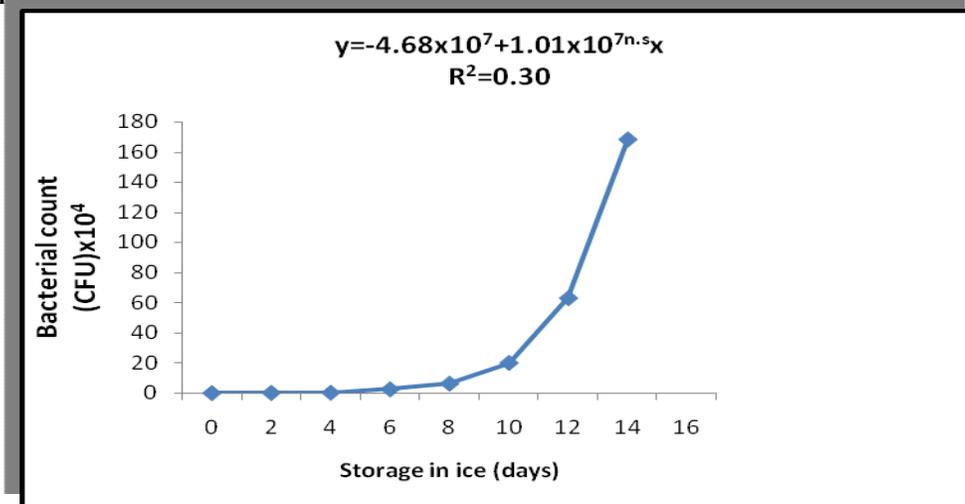


Fig. 4. Changes in psychrophilic aerobic bacterial count (CFU / g flesh) of Nile tilapia during storage in ice at ambient temperature

2. 2. Mesophilic and psychrophilic aerobic bacterial count of grey mullet

Changes in mesophilic and psychrophilic aerobic bacterial count (CFU/g flesh) of grey mullet (*Mugil cephalus*) during storage in ice at ambient temperature are shown in Table (4). The data obtained showed a significant difference ($P < 0.05$) between fresh samples (zero time) and iced samples.

In the present study, initial mesophilic and psychrophilic bacterial count of mullet flesh were 7.67×10^2

and 4.76×10^3 CFU/ g, respectively. Mesophilic and psychrophilic counts reached 2.13×10^4 CFU/g and 1.66×10^5 CFU/ g after 8 day of storage in ice. However, the initial microbial load and the storage time can be influenced by the fish species involved, bacterial load, type of bacteria present and the capture, handling and storing conditions (Huss (1995), Gram and Huss (1996), Andrade *et al.* (2012), Chong *et al.* (2012) and Carracosa *et al.* (2014).

Table 4. Changes in mesophilic and psychrophilic aerobic bacterial count (CFU^{*}/g flesh) of grey mullet during storage in ice at ambient temperature^{}**

Storage in ice (days)	Mesophilic	Psychrophilic
0	$7.67 \times 10^{2c} \pm 2.30 \times 10^2$	$4.76 \times 10^{3c} \pm 7.11 \times 10^2$
2	$1.38 \times 10^{3c} \pm 1.10 \times 10^2$	$1.39 \times 10^{4c} \pm 3.30 \times 10^3$
4	$4.99 \times 10^{3c} \pm 6.00 \times 10^2$	$3.24 \times 10^{4c} \pm 1.81 \times 10^4$
6	$1.13 \times 10^{4c} \pm 1.97 \times 10^3$	$7.67 \times 10^{4c} \pm 1.35 \times 10^4$
8 ^{***}	$2.13 \times 10^{4c} \pm 3.52 \times 10^3$	$1.66 \times 10^{5c} \pm 9.88 \times 10^4$
10	$4.40 \times 10^{4c} \pm 1.45 \times 10^4$	$6.20 \times 10^{5bc} \pm 1.95 \times 10^5$
12	$1.08 \times 10^{5b} \pm 2.03 \times 10^4$	$3.44 \times 10^{6b} \pm 9.42 \times 10^4$
14	$3.52 \times 10^{5a} \pm 7.65 \times 10^4$	$3.00 \times 10^{8a} \pm 0.00$
L. S. D.	4.80×10^4	9.86×10^5

*CFU Colony forming unit.

**Data as mean \pm SD.

*** Organoleptically unacceptable samples.

Means in the same column sharing the same letters are not significantly different at $P < 0.05$ level.

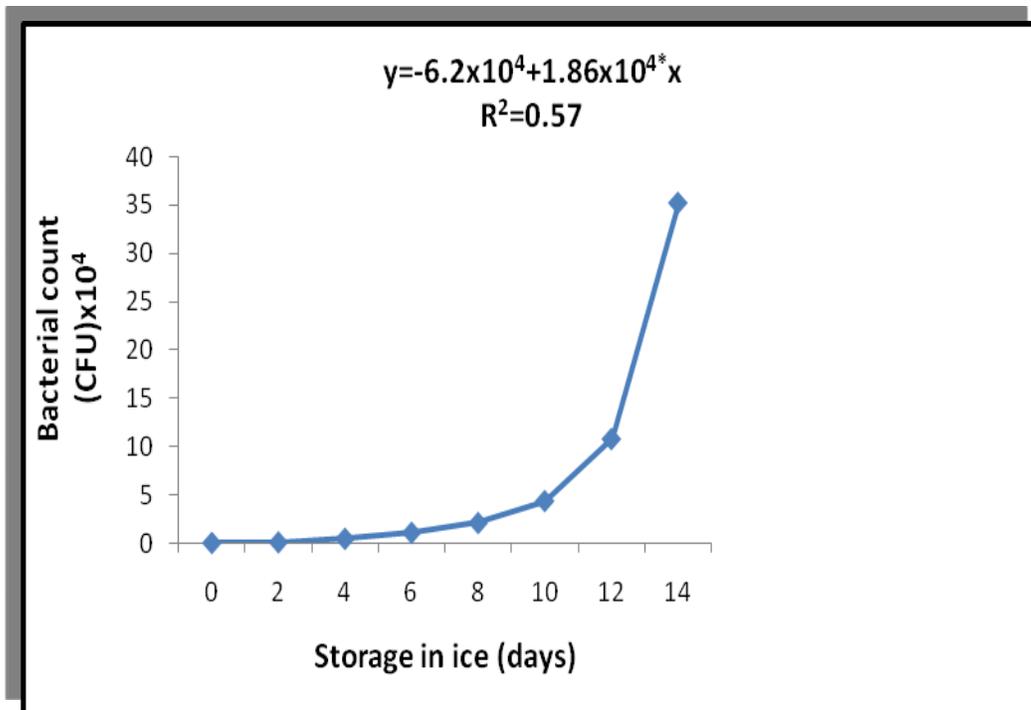


Fig. 5. Changes in mesophilic aerobic bacterial count (CFU/g flesh) of grey mullet during storage in ice at ambient temperature

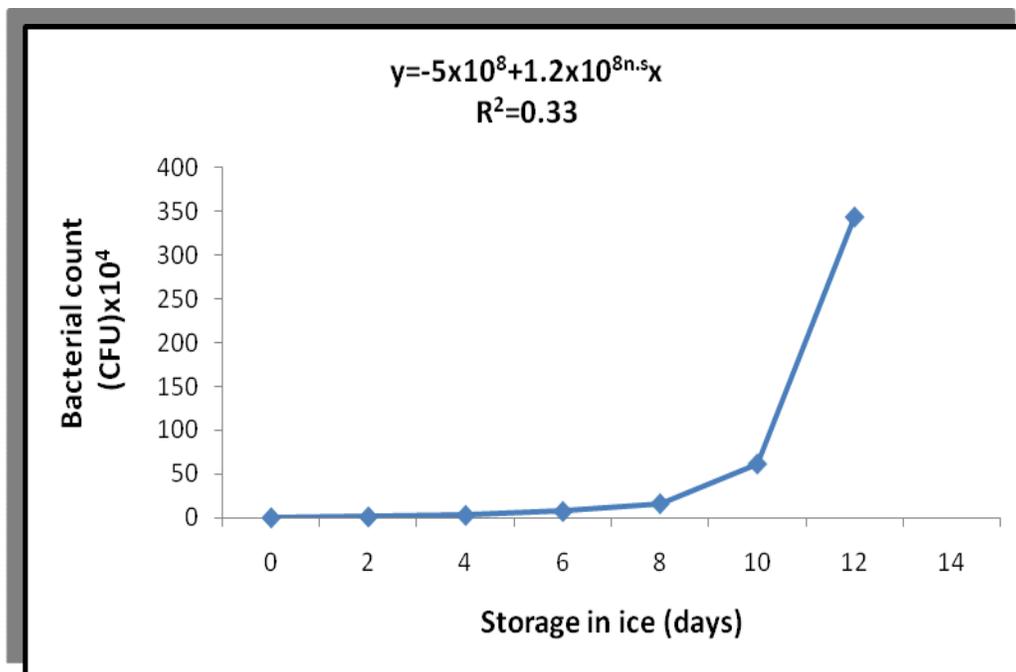


Fig. 6. Changes in psychrophilic aerobic bacterial count (CFU/g flesh) of grey mullet during storage in ice at ambient temperature

It can be noted that the total bacterial population increased sharply (Fig. 5 and 6) and reached 3.52×10^5 and 3.00×10^8 CFU/ g flesh for mesophilic and psychrophilic bacterial count, respectively at the end of storage.

The results obtained in the present study are in a good agreement with those reported by Özyurt *et al.* (2009), Bahmani *et al.* (2011) and Andrade *et al.* (2014).

A significant negative correlation coefficient was observed between the mesophilic bacterial count and sensory evaluation ($R^2=0.82$), which not observed for psychrophilic bacterial count and sensory evaluation ($R^2=-0.64$). A significant regression coefficient was observed between the mesophiles count and the iced storage time ($R^2=0.57$), which not observed for psychrophilic count ($R^2=0.33$).

At the eighth day of storage in ice, mullet samples still had high quality considering that the microbiological upper limit for fresh fish proposed by ICMSF (1986), IFST (1999) and EOS (2005) not exceed 10^6 CFU/g flesh. The values finally rose to an unacceptable value at the end of 14 days storage period.

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الملخص العربي

التغيرات في مؤشرات الجودة الحسية والميكروبيولوجية للبلطي والبوري أثناء التخزين في الثلج

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التخزين بالثلج حيث أصبحت الأسماك غير مقبولة من الناحية الحسية. معدل الزيادة في العد البكتيري للأنواع المحبة للبرودة كان أسرع من معدل الزيادة في العد البكتيري للأنواع المحبة للحرارة المتوسطة خلال فترة تخزين الاسماك بالثلج.

امكن تقسيم جودة أسماك البلطي والبوري بناء على نتائج التقييم الحسي خلال فترة التخزين بالثلج على درجة حرارة الغرفة إلى ثلاث درجات من الجودة على النحو التالي:

١. أسماك البلطي والبوري ذات الجودة العالية، وهي التي لم يمضى على تخزينها في الثلج أكثر من ٤ أيام.
٢. أسماك البلطي والبوري المقبولة، وهي التي خزنت في الثلج أكثر من ٤ أيام وأقل من ٨ أيام.
٣. أسماك البلطي والبوري غير المقبولة، وهي التي خزنت في الثلج لمدة ٨ أيام أو أكثر.

الهدف من هذه الدراسة هو تقدير التغيرات في خواص الجودة الحسية والميكروبيولوجية لكل من البلطي النيلي والبوري خلال التخزين في الثلج لمدة ١٦ و ١٤ يوم على التوالي. ولقد أوضحت نتائج الإختبارات الحسية حدوث انخفاض تدريجي في درجة التقبل العام لكل من البلطي والبوري سواء الخام اوالمطبوخ بالبخار وذلك بزيادة زمن الحفظ بالثلج. ولقد وجد أن الانخفاض في درجة التقبل العام قد ارتبط ارتباطا عالى المعنوية مع الزيادة في زمن التخزين بالثلج واستنادا إلى درجات التقبل العام الحسي، كانت مدة صلاحية البلطي النيلي والبوري ٨ أيام خلال الحفظ بالثلج على درجة حرارة الغرفة. تبين وجود زيادة مستمرة في العد الكلى للبكتيريا الهوائية المحبة للحرارة المتوسطة، والموجودة في لحم أسماك البلطي والبوري بزيادة مدة التخزين بالثلج، حيث ارتفع العد الكلى من 2.38×10^3 و 7.67×10^2 وحدة تكوين مستعمرة /جم لحم سمك عند الزمن صفر من التخزين الى 4.10×10^4 و 2.13×10^4 وحدة تكوين مستعمرة /جم لحم سمك عند اليوم الثامن من