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# Effects of different salt concentrations on the quality alterations and shelf-life of the grey mullet fish

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**ABSTRACT**

The effects of 15 and 20% salt concentrations on the quality and shelf-life of mullet fish (*Mugil capito*) were investigated during three months of storage at ambient conditions (20±1°C). Chemical composition, and physicochemical properties of dry salted mullet were analyzed every 15 days of storage. The results showed that, fresh mullet fish contains (76.52±2.44) % moisture, (18.06±0.87) % protein, (3.99±0.24) % lipid, (1.40±0.04) % ash content. In addition, values of quality attributes were (6.48±0.05) pH, (6.35±1.24) mg\100g TVBN and (1.65±0.01) mg MDA\kg sample TBA. Moreover, concentration (mg\100g) of elements were (0.033±0.010) Cd, (12.24±0.81) Cu, (52.46±1.25) Fe, (1.88±0.11) Mn, (0.550±0.11) Ni, (13.45±0.87) Zn, (87.45±1.21) Ca, (147±2.26) K, (214.78±1.99) P and (80.85±42.11) Na. On the other hand, values of moisture, protein, lipids and pH of both 15% and 20% salted mullet were significantly decreased during storage periods at room temperature, while ash, TBA and TVBN were significantly increased. Mullet fish samples salted with 20% salt concentration recorded a better quality during storage period compared to the other treatment (15%). In conclusion, the present results might provide a scientific basis for optimization and improvement of mullet fish salting technological process.

## 1. INTRODUCTION

Fish salting is considered one of the most common, oldest preservation and processing fish methods due to its part in decreasing water activity and inhibiting bacterial growth **(Clucas & Ward, 1996)**. Furthermore, those methods are not only easy and simple to apply, as cheap raw materials are needed, but easy to access and readily available as well by which preserving fish from autolytic decomposition is attainable. At low salt concentrations, due to high water-protein interaction (maximum water holding capacity), maximum muscle swelling occurs, but at higher salt concentrations, the proteins may have strong protein-protein bonds, resulting in dehydration and promote fat oxidation (**Jittinandana *et al*., 2002; Ghaly *et al*., 2010**; **Guizani *et al*., 2014** and **Chen**

***et al*., 2020).** Many studies were launched on this point; for example, **Jittinandana *et al*. (2002)** found that the increasing brine concentration during fish salting caused a slightly increase in fillet weight loss after salting, cooking yield, shear force, water-phase salt content, brined lipids, pH values, and moisture content of frozen rainbow trout fillets brined in 8.7 or 17.4% NaCl solutions for different times. Besides, the storage time and quality criteria of salted anchovies ,with different concentrations of NaCl at both $4^{oc}$ and ambient temperature, may influence the characteristics of final salted-dried product of different fish species **(Thorarinsdottir *et al*., 2004; Bras & Costa, 2010)**. Moreover, **(Mostafa & Salem, 2015)** investigated changes in the microbiological and physiochemical characteristics in Egyptian salted-fermented fish (Feseikh) during processing, ripening and storage. **El-Shehawy *et al*. (2015)** studied sensory, chemical and physical characteristics of Feseekh (prefermented salted mullet), salted sardine and Meloha from Egyptian Market. **Ahmed *et al*. (2018)** investigated the influence of different salt concentrations levels (20%, 25%, 30% and 0% as a control) on chemical composition of wet-salted fermented product (local name; fessiekh) processed from Shilbaya (*Schilbe spp)* compared with popular fessiekh fish species (*Hydrocynus spp*,). The previous authors found that salt concentration with level 20% showed better results and was more acceptable than the two other concentrations. **Wawire *et al*. (2019)** investigated the effect of salting and pressing process on improving qualities of spotted sardine (*Amblygaster sirm*) stored at different temperature and relative humidity. They concluded that salted fish products had acceptable sensory aspects and prolonged shelf-life, even at ambient conditions, due to salting and pressing which could be considered a simple and appropriate processing technology for pretreatment of salted fish. **Shehata *et al*. (2019)** investigated the effect of salting (at 15% and 20% salt concentrations), with the addition of some natural antioxidants (black seed, grape seed, jojoba extracts and chitosan), on the quality and shelf-life of grass carp, stored at ambient temperature for 28 days. **Gassem (2019)** found that salted fermented mullet fish had 47.96% moisture, 25.71% protein, 19.6% ash, 15.19% salt, 7.25% lipids 78.86 mg/100 g sample TVBN, 6.3 pH value and 32.32 mg MDA/kg TBA. **Chen *et al*. (2020)** investigated the effect of 2%, 6% and 10% salt concentrations and vacuum packaging on storage of Russian sturgeon steaks over a 12 days storage at $4^{oc}$. They found that 2 hrs of salting increased effectively the salt concentration in fish muscle without causing problems, while 6% NaCl was more suitable for inhabitation microbial spoilage, improved the physicochemical, microbiological, sensory criteria and shelf-life of Russian Sturgeon fillets. However, the quality, safety and physicochemical characteristics of salted mullet have not been established, where there is limited information for the best salting conditions of grey mullet fish. Consequently, this study was designed to assess the impact of dry salting at 15 and 20% on the chemical composition, physicochemical quality attributes and shelf-life of mullet fish (*Mugil capito*) samples.

## 2. MATERIALS AND METHODS

### 2.1. Fish samples collection

Fresh 15 kg of mullet fish (*Mugil capito*) were purchased from El-Obor City Fish Market in Egypt, carefully washed with potable water, packed in ice boxes and transported to Fish Processing and Technology Laboratory, National Institute of

Oceanography and Fisheries, El-Kanater El-Khiria City, El-Qaluobia Governorate in Egypt in two hours time. Upon arrival, fish samples were rewashed with potable water, gutted, and rewashed again carefully and drained. The average of total lengths and weights (Mean ± SD) of mullet fish samples were 31.3±1.25 cm and 241±25 g, respectively. Fine refined table salt of sodium chloride (BONO) produced by Egyptian Salts and Minerals Company (EMISAL) was used. It is composed of 98.5% sodium chloride, 30-70 ppm, potassium iodate, and 0.3% humidity.

**2.2. Salted mullet fish processing**

Whole fish were divided into two groups (each one equal weight of 7.5 kg). Dry salting technique was used as followes: each group was thoroughly treated with coarsely ground salt according to the following percentage: group a- whole fish were treated with 15 % salt (w/w); group b- whole fish were treated with 20% salt (w/w). Each fish was salted separately, with coarsely ground salt, applied all over the body especially in the gills area. Then the salted fish samples were packed in plastic containers in different layers, salt was put at the bottom and top of containers and between different layers, and covered with a heavy cover. Salted fish groups were stored at room temperature 20±1°$^{c}$. Random samples were taken on each of the 15$^{th}$ day for the analysis.

**2.3. Physicochemical analysis**

**2.3.1. Chemical composition**

Moisture, crude protein, fat, and ash content were determined using the conventional methods of **AOAC ( 2012)**. To sum up, moisture content was determined by drying the samples in hot air oven for 8 hrs at 105 °$^{c}$ where by the samples reached a constant dried weight. The crude protein content was determined using the semi-micro Kjeldahl method. The crude fat content was determined by the Soxhlet method. Ash content was determined by incineration, whereby the samples were combusted in a muffle furnace at 550–600°$^{c}$ for 5 hrs. Carbohydrates and calorific value were calculated according to (**Davidson *et al*., 1979).**

**2.3.2. Physicochemical quality analysis**

The pH values were determined using a digital pH meter (HANNA, pH213) according to **Goulas *et al*. (2005)** method. Total volatile basic nitrogen (TVBN) was determined as described by **Mwansyemela (1973)**. Thiobarbituric acid (TBA) value was determined by the distillation method outlined by **Tarladgis *et al.* (1960)**.

**2.3.3. Minerals and heavy metals concentrations**

Concentrations of calcium, potassium, phosphorus, sodium, cadmium, copper, iron, manganese, nickel and zinc were determined using the inductively coupled plasma optical emission spectrophotometer (ICP-OES) (Model 4300 DV, Perkin Elmer, Shelton, CT, USA) according to the method of **AOAC (1999**).

**2.3.4. Statistical analysis**

Results were expressed as mean ± SD. and analyzed by using Microsoft Excel 2010. Data were subjected to analysis of variance (ANOVA).

## 3. RESULTS and DISCUSSION

**3.1. Physicochemical composition of fresh mullet fish**

**3.1.1. Chemical composition of fresh mullet fish**

Chemical composition of fresh mullet fish samples is shown in Table 1. The results showed that moisture, crude protein, lipid, ash, carbohydrates and calorific values of fresh mullet fish samples were 76.52±2.44 %, 18.06±0.87 3.99±0.24 %, 1.40±0.04 %, 0.03±0.00 %, and 108.27±3.54 kcal/100 g), respectively. Chemical composition of fish is varying according to nutrition, size of fish, habitat, fishing season, and gender, as well as variations in environmental conditions. This finding matches with **Saldanha *et al*. (2008)** and **Rehbein and Oehlenschlager (2009)**. Similar results were recorded also by **El-Sherif and Abd El-Ghafour (2016)** considering moisture, crude protein, crude fat, ash, carbohydrates and calorific value of fresh mullet fish (*Mugil cephalus*). Moreover, **Boran and Karaçam (2011)** suggested that other reasons can bring variability in the proximate composition of small-sized fish, like species specific physiological characteristics, due to physiological reasons and changes in environmental conditions, such as spawning, migration, and starvation or well-feeding. **Shalaby (1990)** found similar results in moisture and protein, but total lipid was higher (wet weight) than that in the present results. However, **Ibrahim (2013)** recorded slightly lower value in the previous parameters except for moisture and carbohydrates.

Table (1): Chemical composition (%) of fresh mullet fish (*M. capito*) samples.

| Parameters | Values (%) |
|---|---|
| Moisture | 76.52±2.44 |
| Crude protein | 18.06±0.87 |
| Lipid | 3.99±0.24 |
| Ash | 1.40±0.04 |
| Carbohydrates | 0.03±0.00 |
| Calorific value (kcal/100 g) | 108.27±3.54 |

### 3.1.2. Physicochemical quality analysis

Physicochemical quality properties of fresh mullet fish samples are shown in Table (2). The results revealed that pH value, TVB-N and TBA of fresh mullet fish samples are 6.48±0.05, 6.35±1.24 mg/100g and 1.65±0.01 mg MDA/kg sample, respectively. Similar finding was reported by **El-Sherif and Abd El-Ghafour (2016)** evaluating pH value of fresh mullet fish (*Mugil cephalus*) samples, but they recorded a higher value for TVB-N (12.22±0.06). In addition, **El-Sherif *et al*. (2016)** recorded lower values for TBA (0.48 & 0.58 mg MAD/kg), while higher values were recorded for TVBN content (11.35 and 12.05 mg/100g) in fresh mullet fish samples obtained from 1$^{st}$ and 2$^{nd}$ Wadi El-Rayan Lake**.**

Table (2): Physicochemical properties of fresh mullet fish (*M. capito*).

| Parameters | Values |
|---|---|
| pH value | 6.48±0.05 |
| TVBN (mg/100g, ww) | 6.35±1.24 |
| TBA (mg MDA/kg, ww) | 1.65±0.01 |

### 3.1.3. Heavy metals concentrations of fresh mullet fish

Heavy metals concentrations of fresh mullet fish samples are shown in Table 3. The order of heavy metals concentrations in fresh mullet fish samples was as follows: Fe 52.46±1.25>, Zn 13.45±0.87>, Cu 12.24±0.81 >, Mn 1.88±0.11>, Ni 0.550±0.11>, Cd 0.033±0.010, mg/100g on dry weight. The present results are higher than that obtained by **Talab *et al.* (2014)** of *Mugil cephalus*. However, the levels of heavy metals in the present study were lower than the maximum permissible levels for fresh mullet fish samples (1, 30, 100, 7-8 and 100 mg/100g) for Cd, Cu, Fe, Ni and Zn, respectively, as set by **WHO (1989)** except for Mn which showed a higher value.

Table (3): Heavy metals concentrations of fresh mullet fish (*M. capito*).

| Metals | Values (mg/100g dw) |
|---|---|
| Cd | 0.033±0.010 |
| Cu | 12.24±0.81 |
| Fe | 52.46±1.25 |
| Mn | 1.88±0.11 |
| Ni | 0.550±0.11 |
| Zn | 13.45±0.87 |

### 3.1.4. Minerals concentrations of fresh mullet fish

Minerals concentrations such as sodium, potassium, magnesium, calcium, iron, phosphorus, selenium, zinc, copper and manganese are important for human nutrition (**Guerin *et al.*, 2011**). As shown in Table (4), fresh mullet samples contained (87.45±1.21) Ca, (147±2.26) K, (214.78±1.99) P and (80.85±42.11) Na mg/100g (on dry weight basis). Fresh mullet fish samples contained appreciable amounts of Ca, Na, K and P; a result which suggests that these fish species could be used as good sources of minerals in fresh process condition. These findings agree with those of **Nahid *et al.* (2017)**, whereas they are lower than that recorded by **El-Sherif and Abd El-Ghafour (2016)** who concluded that calcium, phosphorus, potassium and sodium in fresh mullet fish (*Mugil cephalus*) samples were 185±0.12, 410±0.08, 412±0.42 and 85±0.11 mg/100g fish muscle (on wet basis), respectively.Values of calcium, sodium, potassium, and phosphorus in the fresh mullet fish were within the permissible range; 19-881, 19-502, 68-550 and 30-134 mg/100g, respectively, as set by **FAO\WHO (2011)**.

Table (4): Mineral concentrations of fresh mullet fish (*M. capito*).

| Minerals | Values (mg/100g dw) |
|---|---|
| Ca | 87.45±1.21 |
| K | 147±2.26 |
| P | 214.78±1.99 |
| Na | 80.85±42.11 |

### 3.2. Effect of different salt concentrations on chemical composition of mullet fish stored at (20±1°C)

#### 3.2.1. Moisture content

Moisture content in fresh mullet fish was 76.52±2.44 %, while 15% and 20% salted mullet recorded 75.46±2.04 % and 74.72±1.24 %, respectively, at zero time of storage (Figure1A). A decrease in moisture content was observed in 20% salt concentration samples compared to that of the 15% . Moisture content of salted mullet was less than that of raw fillets. Increasing brine concentration decreased moisture content of salted fish significantly ($p < 0.05$). The obtained results are congruent with those reported by **Aman (1978)** who found that moisture content decreased from 78.31% in fresh fish to 67.15% after six weeks of salted mullet fish. Furthermore, **Jeyasanta *et al.* (2016)** reported that moisture content decreased with the increase of the percentage of salt in wet salting. On the other hand, **Rashad (1986)** found that a slightly decrease in moisture content occurred during the first week of salted mullet fish, while the moisture content, in lightly salted mullet fish, reached the maximum decline on the third week, and remained constant at the end of salting process. Addingly, **Yasin (1997)** and **Hernandez-herrero *et al.* (1999a)** observed that a progressive loss in moisture content correlated with the increase in protein, lipid, salts and ash. **Ibrahim (2013)** reported that the moisture of fresh mullet fish decreased after 15 day of storage in dry salting in whole salted mullet with 15, 20 and 25% salts. The moisture content in the salted mullet fish decreased, with increasing storage time and increasing salt concentrations, during different storage time. This finding agrees with **Ariyarathna (2011)** who detected a significant decrease in moisture content of herring, recording 68.0% to 63.6% , after brining for 24 hours in 20% brine solution.

#### 3.2.2. Crude protein content

Crude protein of fresh mullet fish was 18.06±0.87 %, while it ranged in salted mullet, at zero time, between 17.67±0.58 % at 20% salt and 17.69±0.54 % at 15% salt (Figure 1 B). Protein content decreased significantly during storage period in both different salt concentrations, whereas, the decrease rate was higher in the 20% salt trial. During different storage periods, crude protein, in the salted mullet fish, decreased with the increase of storage time and salt concentration. The present data are relatively in accordance with that obtained by **Yasin (1997)** who found a slightly decrease in crude protein by 6.7% (dry weight) of 20% NaCl brined mullet for 48 hrs at 20 $^{oc}$. Also, **Hernandez-hererro *et al.* (1999a)** found that the protein content decreased markedly after six weeks ( from 20.44% to 17.81%) in anchovy muscle. Moreover, **Ibrahim (2013)** revealed that protein content, after three months, decreased with the increase in salt concentration, in whole and gutted salted mullet samples in 15days of time. However, **Chaijan (2011)** and **Thorarinsdottir *et al.* (2011)** depicted an increase in protein content during salted Tilapia production.

#### 3.2.3. Lipid content

Lipid in the salted mullet fish decreased with increasing storage time and increased with increasing salt concentration during different storage time (Figure 1 C). These results agree with those of **El-Sharnouby (1989)** who stated that salting and curing process led to a reduction in the total lipids of fish congruent with increasing storage period. Moreover, **Ibrahim (2013)** reported that lipid content of fresh mullet fish decreased after 15 storage-days of dry salting in whole salted mullet with increasing

concentration of salt. While, **Hernandez-herrero *et al*. (1999a)** observed a relatively increase(from 3.24% to 4.70 %) in fat content in wet weight salted anchovy after 8 weeks of salting.

### 3.2.4. Ash content

Ash content in the salted mullet fish increased with increasing storage time and with increasing salt concentration during different storage time (Figure 1 D). The present data coincides with that obtained by **Ibrahim (2013)** who stated that ash content of fresh mullet fish increased in whole salted mullet with increasing concentrations of salt, while it differs with that of **Fuentes *et al*. (2010**) and **Chaijan (2011)** who declared that salting process caused a slightly decrease in ash content during storage

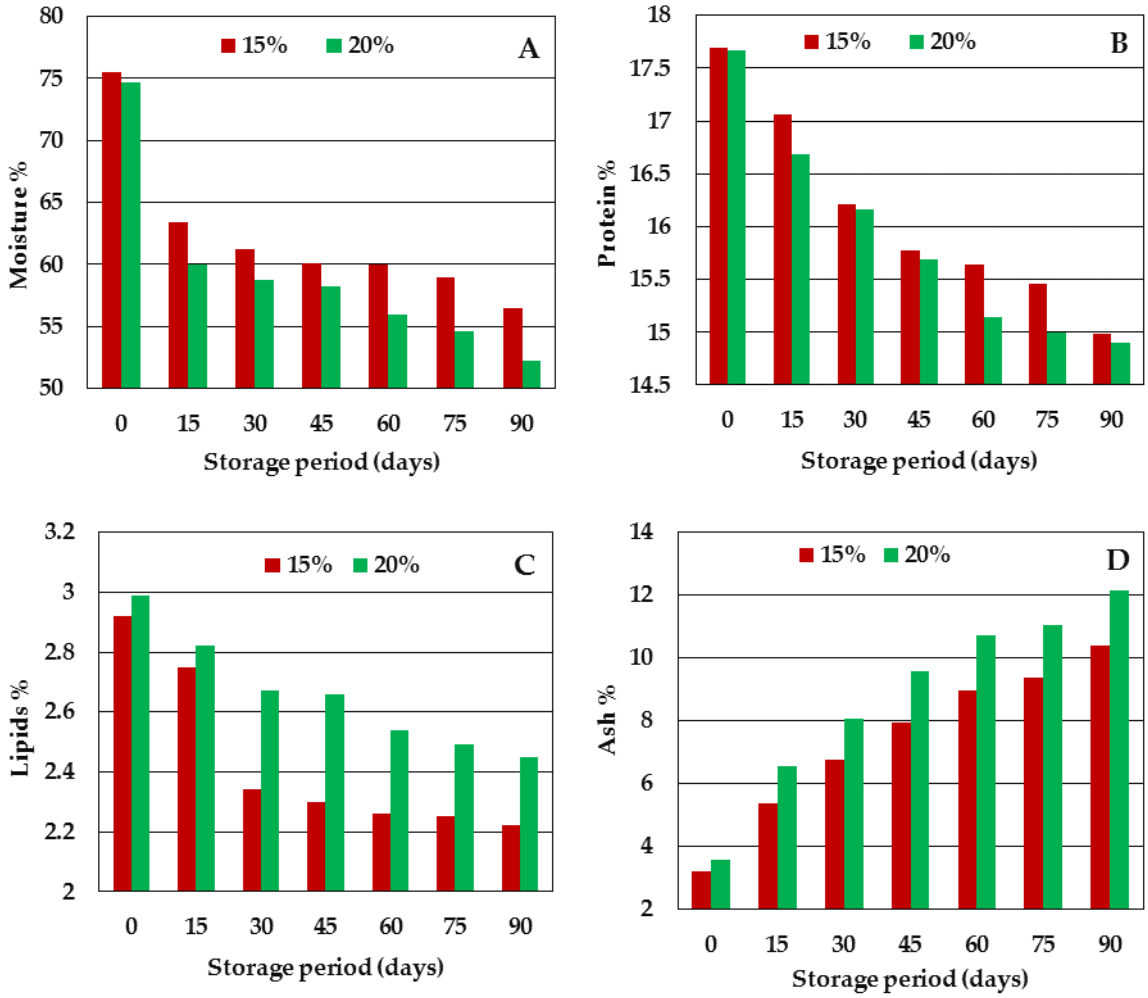


**Figure (1).** Effect of 15 and 20% salt concentrations on moisture (A), protein(B), lipids (C), and ash (D) contents of mullet fish (*M. capito*) stored at (20±1°ᶜ).

## 3.3. Physicochemical quality criteria of salted mullet fish

### 3.3.1. pH value

The pH value in fresh mullet fish was 6.48±0.05, while it decreased slightly in the salted samples (Figure 2 A) with increasing salt concentration and storage periods. It ranged between 6.34±0.02 for 20% salted mullet and 6.39±0.04 for 15% at zero time.

This finding agrees with **Unlusayin *et al.* (2010)** who mentioned that the pH in 8 % brine salted, 20 % brine salted and dry salted of cuttlefish slightly decreased compared to fresh sample. Similar results were recorded by **Ibrahim (2013)** who reported that the pH values of salted mullet fish gradually and continuously decreased from the beginning till the end of storage. Furthermore, **Hernandez-herrero *et al.* (1999a)** exhibited similar data of anchovy pH muscle recording an appreciably decrease. In this essence, **Chaijan (2011)** recorded the decreasing level in the pH of salted *Tilapia* muscle.

### 3.3.2. Total Volatile Basic Nitrogen (TVB-N) and Thiobarbituric acid (TBA)

TVB-N in fresh mullet (6.35±1.24 mg/ 100 g) was lower than salted mullet (Figure 2 B), at zero time, which fluctuated between 14.12±1.65 mg/ 100 g in group B (20%) and 17.22±1.52 mg/ 100 g in group A (15%). However, TBA in fresh mullet (1.65±0.01 mg MDA/ kg) was lower than salted mullet (**Figure, 2 C**), at zero time, which varied from 3.50±0.24 mg mal./ kg in group B to 3.79±0.15 mg MDA / kg in group A.

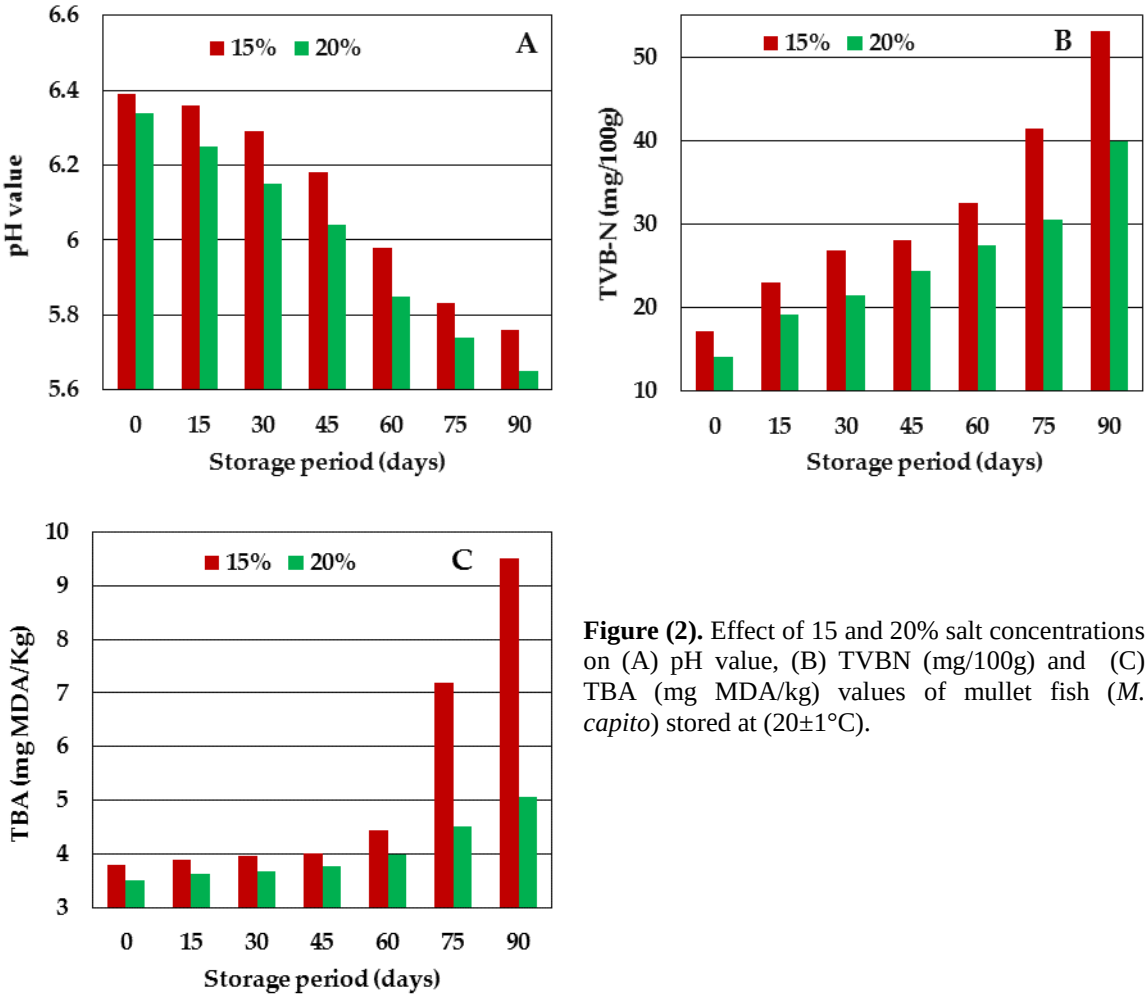


**Figure (2).** Effect of 15 and 20% salt concentrations on (A) pH value, (B) TVBN (mg/100g) and (C) TBA (mg MDA/kg) values of mullet fish (*M. capito*) stored at (20±1°C).

These results showed that TBA and TVB-N decreased with increasing salt concentration and increased with the increasing storage periods.Hence, the current finding agrees with **El-Sharnouby (1989)** who found that the TBA values increased sharply (from 5.93 mg MA/kg) in fresh grey mullet (to 14.43-78.0 mg MA/kg) after 4

weeks from the beginning of salting. Whereas, the current resulted data disagree with that of **Aberoumand (2012)** who mentioned that TBA increased from 0.07 mg MDA/kg in fresh brined to 0.10 after 60 days, and then, decreased to 0.09 mg MDA/kg in vacuum packed (VP) brined golden mullet (90 days of storage). Yet, TVN increased from 10 mg/100 g in fresh brined after 14 days to 30.80 mg/100 g in VP brined Golden mullet after 90 days of storage at 4°$^{c}$. Also**, Ibrahim (2013)** stated that, the physicochemical aspects of fresh mullet fish increased with increasing salt after 15 day storage in whole salted mullet with 15, 20 and 25% salt, respectively, for both TBA and TVBN. Total volatile basic nitrogen (TVBN) and thiobarbituric acid (TBA) values, in the salted mullet fish, increased with increasing storage time, and decreased with increasing salt concentration during different storage time. Similar results were reported by **Sinhuber and Yu (1958)** who found that the good quality fish had TBA less than 3 mg MDA/kg, while poor quality products recorded values from 4-27 mg MDA/kg sample. At the same time, **Reddy and Settee (1996)** found that the decrease in TBA has been attributed to the interaction of decomposition products of protein with maloaldhyde to give tertiary products. Besides, **Hernandez-hererro *et al*. (1999b**) found that the TBA content in raw anchovy fish was 10.75, marking an increase during the first 6 weeks of salting (12.73 mg MA/kg) and thereafter decreased gradually (11.92 and 11.45 mg MA/kg) after 7and 9 weeks of salting, respectively. While, TVB-N of anchovy decreased from 24.0 to 19.9 mg% during the first 7 days of ripening, thereafter, the TVB-N contents of anchovy and brine increased gradually until the end of ripening (9 weeks). On the other hand, the upper mentioned authors concluded that the decrease in anchovy TVB-N content might be due to a part of TVB-N content diffused into the brine with other nitrogen fractions. The present study agrees with **Ibrahim (2013)** who concluded that the increase in TVB-N in whole salted mullet fish and gutted salted fish was detected at the end of storage period. Furthermore, **Reddy and Settee (1996)** found that the TVB-N content of mackerel increased during the storage period. They concluded that the rapid increase in TVB-N value might be due to bacterial and enzymatic reaction, particularly, the growth of halophilic bacteria. At the same time, **Shaheen (1958)** found that the amount of TVB-N decreased in eviscerated and non-eviscerated Bouri tissues during salting due to leaching.

## CONCLUSION

The obtained results revealed that the quality was lower in mullet fish treated with 15% salt, while the physicochemical values (pH, TVBN, TMA) were higher compared to 20% salt treatment. The present study concluded that to obtain better results in salting process, the 20% salt concentration in dry salting method, is more suitable to extend shelf-life of salted mullet products for mullet fish (*Mugil capito*).

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