Effect of Frozen Storage on the Chemical, Physical and Microbiological Quality of Imported Mackerel (Scomber scombrus).

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ABSTRACT

The imported frozen (Mackerel) Scomber scombrus was evaluated for the changes of its quality during freezing storage at -18°C for four months and its compliance with the Egyptian standard specifications. It was found that the protein, lipid and ash contents decreased during the storage period. Furthermore, moisture slightly increased during the storage period. The results also indicated that the samples did not exceed the permissible limits of total nitrogen as determined by the Egyptian Organization for Standardization and the quality of production. Microbiological examination showed a significant decrease [P<0.05] in the total bacterial count between the first and fourth months of storage. Staphylococcus spp. was detected in the first and the second months of surface examination, being 104.70 cfu×10^3 /g and 2.74 cfu×10^3 /g, respectively. In addition, Salmonella was detected in the first month of surface examination. E. coli and Clostridium were absent in all examined samples. Fourteen different bacterial isolates were isolated from all samples. Twelve isolates were isolated from staph 110 medium and two isolates were found on the SS agar medium. Twelve isolates were coccoid shaped and twelve isolates were spore forming rods. All isolates were gram positive. Two isolates were spore forming and twelve isolates were non-spore forming. Six isolates were considered as Staphylococcus sp. and another six isolates were considered as Micrococcus sp. the last two isolates were considered as Bacillus sp. 

Keywords: Scomber scombrus, Chemical characteristics, Microbiological examinations and Frozen storage.

INTRODUCTION

Egypt is considered the second top ten countries consuming Mackerel (Scomber scombrus). Although Egypt came at the first order between Arab countries in fish production, the Egyptian imported fish percentage represented 0.477% in accordance to the world fish production, the Egyptian imported fish percentage represented 0.477% in accordance to the world fish production and there were no exported amounts could be significant during the same year (FAO, 2009). Mackerel (Scomber scombrus) is a migrant type. Spawning followed by migration of adults belongs to the southern and western areas to feed zones in the Norwegian Sea and the North Sea. This species supports valuable fisheries of great importance in several European countries, with annual mean landings of 675000 Tons from 1972 to 2002 (Dobrinas et al., 2011). Atlantic Mackerel (Scomber scombrus) is a worthy specie in the marine industry (Wasik et al. 2015). Mackerel fish are important fishery resources contribute to food materials, exceedingly distributed in the Pacific coast of Japan, East China Sea, and zones of Indian (Zhang and Deng, 2012). Fish have many nutrients, so that it is rapid for spoiled foods. Spoilage of fish directly happened after capture. Changes in the fish are done in 2 days by the flesh enzymes. These enzymatic activities decrease because of low temperature where the microflora and the enzymes are not active in these conditions (Gandotra et al., 2012). Preservation of food is necessary to raise its shelf life, protect its nutritional value, flavor and texture. So that, good methods of food preservation must prevent spoilage of food by microorganisms while maintaining its quality and nutritional value (Ghayl et al., 2010). The extension of shelf life can be achieved by freezing, salting, chilling, glazing, smoking, etc. Freezing creates unfavorable conditions which slow down the microbial growth and the biochemical decomposition of fish muscle (Gandotra et al., 2012). To protect the consumer and ensure the quality of fish coming to the Arab Republic of Egypt, the Egyptian Organization for Standardization and Quality status Egyptian standards used by stakeholders to judge the quality of the various imports and foremost of which is frozen fish, which amounted to Egypt's imports of which 257 thousand tons in 2012 (Hassan et al., 2014). The goals of this study were to: to evaluate the quality of imported frozen Mackerel (Chemical, physical, and microbiological examinations) and insure of the compliance with the Egyptian standard specifications. Finally, study the effect of the freezing storage at -18°C on the quality of frozen fish.

MATERIALS AND METHODS

Fish samples collection:

Imported frozen Mackerel (Scomber scombrus) was produced at: 10/1/2015, with a period of validity up to six months. Fish samples were collected after entering to New Damietta port, Egypt. The fish samples directly transported in frozen transport to the laboratory of Food Industries Department, Faculty of Agriculture, Damietta University. The fish sample was divided into 4 groups to evaluate their quality monthly and for four months from the date of production and examine the effect of frozen storage at -18±2 °C for four months and follow up changes occurred during frozen storage at -18±2 °C for four months.

Analytically Methods:

Physical properties:

Water holding capacity (WHC) was determined as described by (Soloviev, 1966), Drip loss was determined as described by (Wangtueai et al., 2014), pH value and acidity were determined using AOAC (2012) methods.

Chemical analysis:

Fish samples were prepared for chemical analysis by removing the viscera, fins, scales, head and bones. The meat is then taken and mixing well according to EOS (2006).

Moisture, protein, fat and ash and non-protein nitrogen content were determination by the method of AOAC (2012). Total volatile basic nitrogen was done by the method described in EOS (2006). Total soluble nitrogen was determined by a method of (Saeed and
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Physical properties changes of frozen Mackerel during the storage at -18±2°C for four months showed in Table (1). From tabulated data drip loss percentages increased during the storage period from 1.74 ± 0.169% in the first month of the storage to 2.01 ± 0.022% in the fourth month of the storage period. However, there are significant differences [P<0.05] in the drip loss percentages between the first and fourth months of the storage period. The change of myofibril structure, alteration in protein conformation and water retention site in muscles, all of them play an important role in the rise of drip loss Truong et al. (2016). These results agreed with Akter et al. (2014).

As shown in Table 1, the percentage of water holding capacity (WHC) decreased from 58.23±0.666% to 55.38±0.291% during the storage period. Furthermore, there are significant differences [P < 0.05] between the first and fourth months of the storage period in WHC percentages. The decrease in WHC% may be due to biochemical changes in fish muscle such as protein denaturation and lipid oxidation. Furthermore, microbial and enzymatic activities Nguyen et al. (2013). These results agreed with those of Osorio et al. (2015).

Table 1. Physical properties changes of frozen Mackerel during the storage at -18±2°C for four months

<table>
<thead>
<tr>
<th>Storage period (month)</th>
<th>DL%</th>
<th>WHC%</th>
<th>pH</th>
<th>Acidity%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.74±0.169</td>
<td>58.23±0.666</td>
<td>5.96±0.033</td>
<td>1.75±0.057</td>
</tr>
<tr>
<td>2</td>
<td>1.82±0.089</td>
<td>56.83±0.641</td>
<td>5.98±0.088</td>
<td>1.72±0.177</td>
</tr>
<tr>
<td>3</td>
<td>1.88±0.155</td>
<td>56.76±0.596</td>
<td>6.10±0.082</td>
<td>1.61±0.151</td>
</tr>
<tr>
<td>4</td>
<td>2.01±0.022</td>
<td>55.38±0.291</td>
<td>6.20±0.149</td>
<td>1.56±0.033</td>
</tr>
</tbody>
</table>

Preceding data in Table 1 showing that there were significant differences [P<0.05] in pH values of first and fourth months of the storage period. However, values of pH increased from 5.96 ± 0.033 in the first month to 6.20 ± 0.149 in the fourth month of storage period. This rise in pH value can be attributed to the increase of decomposition products such as volatile bases (NH3, TMA and DMA) and accumulation of amines and peptides Ouclif et al. (2012). These results are in agreement with those of Mazrouh (2015). Finally, results in Table 1 showed that, the percentages of acidity decreased during the storage period. Additionally, there were significant differences [P<0.05] between the first and fourth months of the storage period. However, acidity percentages in frozen Mackerel varied from 1.75 ± 0.057% to 1.56 ± 0.033%. These results are consistent with the results recorded by El-Dengawy et al. (2012).

Gross chemical composition:

Approximate composition of frozen Mackerel during the storage at -18±2°C for four months are shown in Table 2. Results showed that, there was slight rise in moisture content from 71.98 ± 0.483% to 72.84 ± 0.220% during the storage at -18±2°C for four months. However, there were no significant differences [P<0.05] among the storage time. These results may be due to reactivity between formaldehyde or malanoaldehyde (breakdown product of trimethylamin (TMA) and total lipid) and tissue protein with liberation of water, rise forming of TMA and
TVB result to rise in moisture and lack of protein and lipid content. These results are in accordance with those of Mohamad and saad (2015).

As shown in Table 2 there was no significant [P<0.05] decrease in protein content. However, it decreased from 68.35 ± 0.471 to 68.12 ± 0.583 during the storage period. These results can be attributed to the effect of freezing and autolytic deterioration connecting with the activity of endogenous enzymes and bacteria during the storage Aberoumand (2013). Similar results were observed by Mazrouh (2015) who found that protein content in Saurida undosquamas decrease from 23.12±1.99 to 13.46±1.32 after 7 and 21 days of storage at -20°C, respectively.

Table 2. Approximate composition of frozen Mackerel during the storage at -18±2°C for four months

<table>
<thead>
<tr>
<th>Storage period/ month</th>
<th>Moisture %</th>
<th>Protein %DB</th>
<th>Fat % DB</th>
<th>Ash % DB</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>71.98±0.483</td>
<td>68.35±0.471</td>
<td>28.49±0.412</td>
<td>3.14±0.127</td>
</tr>
<tr>
<td>2</td>
<td>72.22±0.626</td>
<td>68.31±0.418</td>
<td>28.47±0.490</td>
<td>3.10±0.138</td>
</tr>
<tr>
<td>3</td>
<td>72.40±0.635</td>
<td>68.22±0.723</td>
<td>28.43±0.497</td>
<td>3.05±0.206</td>
</tr>
<tr>
<td>4</td>
<td>72.84±0.220</td>
<td>68.12±0.583</td>
<td>28.40±0.589</td>
<td>2.99±0.158</td>
</tr>
</tbody>
</table>

Mean ± SD the small letters in the same column means no sig. diff. However, there was no significant decrease in fat content during storage of frozen Mackerel at -18±2°C for four months. However, the highest value of fat content 28.49 ± 0.412% was observed in the first month and the least 28.40 ± 0.589% was recorded in the fourth month of the storage period. This decrease may be due to unsaturated fatty acids oxidation and enzymatic hydrolysis in fish and triglyceride fraction loss Mazrouh (2015). Similar results were observed by Alam et al. (2012) and Mazrouh (2015).

Ash content in selected fish samples slightly decreased during the storage period from 3.14 ± 0.127% to 2.99 ± 0.158%. However, there were no significant differences in the ash content among the storage period. Those results may be due to muscle content of minerals, physiological parameter and alimentation Mazrouh (2015). These results agreed with those of Roopma et al. (2013). From previous results, it could be concluded that, the nutritional value of fish in terms of the content of protein, fat and ash are very important for human health, not just its suitability for human consumption. Therefore, it is recommend to modify them to the Egyptian standard specifications by including these parameters during fish examination.

Protein fractions:

Table 3 showed protein fractions of frozen Mackerel during the storage at -18±2°C for four months. Results in Table 3 showing that, there were significant differences [P<0.05] between the first and fourth months in the percentages of the total soluble nitrogen (TSN). Which decreased from 4.94 ± 0.131% to 4.60 ± 0.007% during the storage period. Those results may be due to muscle content of minerals, differences [P<0.05] between the first and fourth months of the storage time. Those results may be due to the high activity of bacteria and of proteolytic enzymes Ramesh et al. (2013). Similar results were recorded by Ramesh et al. (2013).

Table 3. Protein fractions of frozen Mackerel during the storage at -18±2°C for four months

<table>
<thead>
<tr>
<th>Storage period/ month</th>
<th>TSN</th>
<th>NPN</th>
<th>FAN</th>
<th>TVB-N mgN/100g</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.94%±0.131</td>
<td>0.271±0.024</td>
<td>0.23±0.010</td>
<td>0.008</td>
</tr>
<tr>
<td>2</td>
<td>4.80%±0.216±0.287±0.0130.255±0.0720.65±0.789</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.74%±0.282.0.308±0.040.273±0.00721.09±0.171</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4.60%±0.122</td>
<td>0.315±0.018</td>
<td>0.275±0.040</td>
<td>21.89±0.098</td>
</tr>
</tbody>
</table>

Mean ± SD the small letters in the same column means no sig. diff. Data in Table 3 showing that, free amino nitrogen (FAN) % increased during the storage period from (0.238 ± 0.008%) to (0.275 ± 0.040%). Furthermore, there were significant differences [P<0.05] in FAN% between the first and fourth months of the storage time. Those results may be due to the action of bacteria and endogenous enzymes Hassanin and El-Daly (2013). Similar results were obtained by Paola and Isabel (2015).

Bacteriological examination of frozen Mackerel during the storage at -18±2°C for four months.

Table 4 showing the total bacterial count in surface of frozen Mackerel during the storage at -18±2°C for four months. Results in Table 4 showed the total bacterial count in surface of frozen Mackerel during the storage at -18±2°C for four months.

Table 4. Surface bacteriological examination of frozen Mackerel during the storage at -18±2°C for four months

<table>
<thead>
<tr>
<th>Storage period/ month</th>
<th>Total Bacterial Count</th>
<th>Salmonella spp. Count</th>
<th>Shigella spp. Count</th>
<th>Staphylococci spp. Counts</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>102.88±50.000</td>
<td>3.17±0.061</td>
<td>ND*</td>
<td>104.70±5.556</td>
</tr>
<tr>
<td>2</td>
<td>99.52±50.020</td>
<td>ND*</td>
<td>2.74±0.004</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>77.06±0.601</td>
<td>ND</td>
<td>ND</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>46.56±0.800</td>
<td>ND</td>
<td>ND</td>
<td></td>
</tr>
</tbody>
</table>

*ND: means not detected, Mean ± SD. The smaller letters in the same column means no sig. diff. Data in Table 4 showed that, surface total bacterial counts were 102.88 ± 50.00, 99.52 ± 0.502, 77.06 ± 0.601 and 46.56 ± 0.800 (cfu/103/g) in 1st, 2nd, 3rd and 4th month, respectively. Furthermore, there were significant differences [P<0.05] between the first and fourth months of the storage period. However, total bacterial count decreased during the storage of Mackerel at -18±2°C for four months.
These decreases can be attributed to the frozen storage effect (Mahmoud, 2004). The data in the present study are in accordance with those published by Al-Harbi and Uddin (2005).

The human bacterial pathogens Salmonella spp and Shigella spp were detected only in the first month of storage period with total count of 3.17 ± 0.061 cfu×10³/g). These results are in agreement with those of Tayo et al. (2012b). Escherichia coli was not found among the storage at -18±2°C for the examined four months. Whereas, Staphylococcus spp. was only detected in the first and second months of the storage being 104.70 ± 0.556 cfu×10³/g, 2.74 ± 0.004 cfu×10³/g in the first and second months, respectively, and not detected in the third and fourth months of the storage period. Appearance of Salmonella spp and Shigella spp and Staphylococcus spp may be due to the fish handling with contaminated hands and bacteria could be found on skin, chitinous shell (Emikpe et al., 2011). These results agreed with those of Tayo et al. (2012a). Finally, Clostridium spp was not detected on surface of the selected fish during the storage at -18±2°C for the examined four months. Similar results were obtained by Rokibul et al. (2013).

Dorsal muscle bacteriological examination:

Table 5 showing total bacterial counts in the dorsal muscle of frozen Mackerel during the storage at -18±2°C for four months. Results in Table 5 indicated that, total bacterial count decreased during the storage time from 6.15 ± 0.042 cfu×10³/g in the first month to 3.30 ± 0.078 cfu×10³/g in the fourth month of storage time. Furthermore, there were significant differences [P˂0.05] between the first and fourth months. The present data are in accordance with those published by Mahmoud (2004).

Table 5. Dorsal muscle bacteriological examination of frozen Mackerel during the storage at -18±2°C for four months

<table>
<thead>
<tr>
<th>Storage period/ (month)</th>
<th>Dorsal muscle examination (cfu×10³/g)</th>
<th>TBC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.15±0.042</td>
<td>TBC</td>
</tr>
<tr>
<td>2</td>
<td>6.00±0.052</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4.35±0.055</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.30±0.078</td>
<td></td>
</tr>
</tbody>
</table>

Mean ± SD. The smaller letters in the same column means no sig. diff.

The decrease in total bacterial count during storage period can be attributed to freezing which is known to reduce viable cell counts by 1-2 Log units, with the increase of storage time, and the reduction in viable cell was increased Oraei et al. (2011). Salmonella sp., Shigella sp., E. coli, Staphylococcus sp. and Clostridium sp. bacteria were not detected in all samples during the storage. These results are in agreement with those by Mahmoud (2004) and Phadke et al. (2012).

These results can be due to that, most pathogens don’t multiply at temperature of freezer and many of them die because their enzymes don’t work properly to maintain normal cell activity. As well, pathogens need water to grow and freezing turns the available water into ice crystals Oranusi et al. (2014). Furthermore, the absence of E. coli may be attributed to that samples not contaminated with fecal or may be due to frozen storage effect as reported by Phadke et al. (2012).

From these results of total bacterial count of dorsal and surface in Mackerel during the storage period, it could be concluded that, the total bacterial counts in the surface of all samples were higher than that found in dorsal muscle of the same samples. These results can be due to the skin, improves the growth of both anaerobic and aerobic bacteria (Tayo et al., 2009). These results are in agreement with that found by Tayo et al. (2012a) and Sichewo et al. (2014).

Characterization and identification of bacterial isolates:

Fourteen bacterial isolates were obtained from all fish samples. Twelve different bacterial isolates were isolated from the staph. 110 medium (Nos. 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13 and 14) and two isolates from SS agar medium (Nos. 9 and 10). The characterization of bacterial isolates were as following: 12 isolates were cocci and 2 isolates were long rods. All isolates were Gram positive. 2 isolates were spore formers and 12 isolates were non spore formers.

Typical colonies representing Staphylococci growth, creamy or orange color colonies were picked up and streaked onto the same media slant. After growth, spherical cells, Gram positive, arranged in irregular clusters. Isolates Nos. 3, 5, 7, 8, 11 and 14 were considered as Staphylococcus sp. according to Bergey’s Manual of Determinative Bacteriology Holt et al. (1994). Isolates Nos. 1, 4, 9, 10, 12 and 13 were considered as Micrococcus sp. These results are consistent with that obtained by Eze et al. (2011) who isolate Staphylococcus aureus from frozen Mackerel fish (Scomber scombrus). Also, Odebiyi et al. (2013) isolated Staphylococcus aureus, Staphylococcus epididemis and Micrococcus sp. from the fish samples.

Colonies which were white, yellow or orange were picked up and streaked onto the same specific media slant. After growth, the cells were long rods, Gram positive and spore forming. Its arrangement were single, pair or chains. Isolates Nos. 2 and 6 were considered as Bacillus sp. according to Bergey’s Manual of Determinative Bacteriology Holt et al. (1994). Similar results were obtained by Odebiyi et al. (2013) who isolated and identified Bacillus subtilis from the fish samples.

CONCLUSION

Finally, it could be concluded that, the nutritional value of fish in terms of the content of protein, fat and ash are very important to human health, not just its suitability for human consumption. Therefore, it is recommend adding them to the Egyptian standard specifications examine fish. Frozen Mackerel samples had dorsal total bacterial counts less than the permissible limit of the Egyptian Organization for Standardization (EOS) and these samples are accepted according to the EOS.

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