

## RESEARCH ARTICLE

### Quality Parameters of Some Marketed Frozen Fish in Dakahlia Governorate, Egypt

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#### Abstract

Fish deteriorative changes could occur directly after catching, storage, and retailing. One hundred samples of *Scomber scombrus* (*S. scombrus*), *Clupea pilchardus* (*C. pilchardus*), *Pagrus pagrus* (*P. pagrus*), *Oreochromis niloticus* (*O. niloticus*), and *Mugil cephalus* (*M. cephalus*) (20, each) were randomly collected from different fish markets at Dakahlia Governorate, Egypt. The respective mean values of pH, total volatile basic nitrogen (TVB-N mg/100g), and thiobarbituric acid (TBA mg/kg) were  $6.52 \pm 0.11$ ,  $37.75 \pm 4.79$  and  $3.91 \pm 1.7$  in *S. scombrus*,  $6.45 \pm 0.28$ ,  $41.41 \pm 5.62$  and  $3.25 \pm 1.24$  in *C. pilchardus*,  $6.58 \pm 0.06$ ,  $45.97 \pm 6.61$  and  $3.25 \pm 1.4$  in *P. pagrus*,  $6.75 \pm 0.22$ ,  $23.5 \pm 3.35$  and  $1.20 \pm 0.42$  in *O. niloticus*,  $6.68 \pm 0.16$ ,  $30.82 \pm 4.32$  and  $1.75 \pm 0.38$  in *M. cephalus*. The histamine value in *S. scombrus* was significantly higher ( $p < 0.05$ ) than other species, but all examined samples were within the permissible limit. The *P. pagrus* species contained significant higher ( $P < 0.05$ ) aerobic plate count (APC), *Pseudomonas* spp, and *Staphylococcus aureus* (*S. aureus*) in comparison to other species. The *O. niloticus* contained the lowest microbial counts, chemical changes, and histamine. The examined fish was contaminated with *S. aureus* and *Pseudomonas*; in addition to some samples have high level of TVB-N and TBA than the recommended level. The level of histamine in the examined fish was below the level that induces public health hazard or toxicity.

**Keywords:** *Staphylococcus aureus*, frozen fish, TVB-N, TBA, *Pseudomonas*, Histamine

#### Introduction

Fish is a good source of protein, fat, and minerals that are necessary for a healthy body's stability, and it is regarded as a good food component for a huge portion of the world's population. Food processors, customers, and public health officials are all concerned about the quality of fish. From a food safety standpoint, it is critical to produce safe and acceptable fish and fish products by controlling contamination. Fish quality decreases as a result of a complex process including sensory, chemical, and microbiological deterioration [1]. Fish accounts for over 60% of the world's protein, with 60% of the developing world getting more than 30% of their animal protein from fish. Because of its great biological value and high protein retention in the body, fish protein

has excellent nutritive value. Low fat content and cholesterol levels in most fish products are important aspects of people's health, especially in nations where cardiovascular disease mortality is high and amino acids are scarce [2]. After a fish is caught, it begins to spoil quickly, and rigor mortis is to blame for the changes in the fish after it has died. The odor, flavor, and texture changes that occur during the spoilage process are caused by the breakdown of various components and the formation of new compounds. Deterioration occurs quickly due to various mechanisms triggered by microorganism metabolic activity, endogenous enzymatic activity (autolysis), and chemical oxidation of lipids [3]. The first process that causes fish to deteriorate is microbial growth, which is the rotting factor that has the greatest impact on the quality of

fresh or minimally preserved fish. The fish muscles are initially sterile, however, they become infected after death due to the microbial population found on the fish skin [4]. Because of the high-water activity, low acidity ( $\text{pH} > 6$ ), and high number of non-protein nitrogenous substances found in fish, the bacteria proliferate quickly, causing undesired changes in appearance, texture, flavor, and odor, and lowering the product's quality [5]. Microorganisms produce volatile amines, biogenic amines, organic acids, sulphides, alcohols, aldehydes, and ketones, all of which have unpleasant and unacceptably strong off-flavors. Biogenic amines, such as histamine, cadaverine, tyramine, and putrescine, are the major chemicals created during microbiological spoilage. They are produced by bacterial decarboxylation of certain free amino acids during storage and are used to assess fish safety and quality [6]. The current study aimed to detect the bacteriological and chemical parameters in addition to histamine to assess the quality and safety of marketed frozen fish in the study area.

## Material and methods

### Sample collection

One hundred samples of *Scomber scombrus*, *Clupea pilchardus*, *Pagrus pagrus*, *Oreochromis niloticus*, and *Mugil cephalus* (20, each) were randomly collected from different fish markets at Dakahlia Governorate, Egypt, during February–August 2021. The fish samples were identified and packaged separately in sterile plastic ziplock bags (Mayank Plastics, Delhi, India), then maintained in an insulated box with ice packs ( $4\text{ }^{\circ}\text{C}$ ) and then delivered to the Food Control Laboratory, Faculty of veterinary Medicine, Zagazig university, Egypt within 2 hours. Using sterile scissor and scalpel, the scales and skin of each fish sample were removed aseptically. Between each fish sample, the scissor and scalpel were disinfected with 70 % ethyl alcohol. Thereafter, 25 g of each fish sample was placed in a sterile Whirl-Pak sample bag made of polyethylene (Thomas Scientific, Inc.) with 225 mL sterile buffered peptone water (Oxoid,

CM509). Each bag was sealed, and then homogenized for 1 minute using a stomacher (Merck, Darmstadt, Germany) according to International Standard Organization (ISO) [7]. A sterile pipette was used to transfer the homogenate. One milliliter was put into a sterile test tube containing 9 mL of 0.1 percent peptone water (Conda, Spain), and a 10-fold serial dilution up to  $10^7$  was prepared.

### Bacteriological parameters

According to International Standard Organization (ISO) [7], the aerobic plate counts (APCs) were detected using 0.1 mL of sample homogenate from the selected dilutions onto duplicate sterile plates pre-poured with standard plate count agar (Nissui Pharmaceutical Co., Ltd., Tokyo, Japan) and incubated at  $35\text{ }^{\circ}\text{C}$  for 48 h. The technique of *Staphylococcus aureus* count was applied according to ISO 6888-1[8]. Briefly, 0.1 ml from each of the prepared dilutions was spread onto duplicate plates of Baird Parker (BP) agar (Oxoid CM 275, Canada), supplemented with egg yolk tellurite emulsion (50 ml/L, Oxoid SR54, Canada) and incubated at  $37^{\circ}\text{C}$  for 24-48 h. Pseudomonas counts were carried out according to ISO 13720 [9] on the pseudomonas agar base (CM 559; Oxoid, Canada) supplemented with cetrimide, fucidin, and cephaloridine supplements (SR 103; Oxoid, Canada). Pseudomonas colonies were counted after incubation of plates at  $25\text{ }^{\circ}\text{C}$  for 48 h.

### Chemical parameters

The total volatile basic nitrogen (TVB-N) level of fish was detected according to Malle and Tao [10]. The TVB-N content was measured in milligram of nitrogen per 100 gram of fish. For each tested fish sample, four replicates were created. The thiobarbituric acid (TBA) assay was carried out according to Schmedes and Holmers [11]. The fish sample (10 g) was combined with 25 mL of 20% trichloroacetic acid (w/v) and homogenized for 30 seconds in a blender. The filtrate (2 mL) was added to 2 mL of 0.02M aqueous TBA in a test tube after filtering. The test tubes were incubated at room temperature in the dark for 20 h. The absorbance was measured using a

UV-vis spectrophotometer (Thermo fisher Scientific, USA) at 532 nm. The RIDASCREEN histamine kit (R-Bipharm AG, Germany) was used to determine histamine according to the manufacturer's recommendations. The detection limit for frozen fish is 2.5 ppm. On the enzyme linked immunosorbent assay (ELISA) plate reader, optical density was estimated at 450 nm according to the manufacturer instructions (R-Bipharm AG, Germany). The quantity of histamine in the fish sample was inversely proportional to the amount of complex bound to the plate and the optical density.

### Statistical analysis

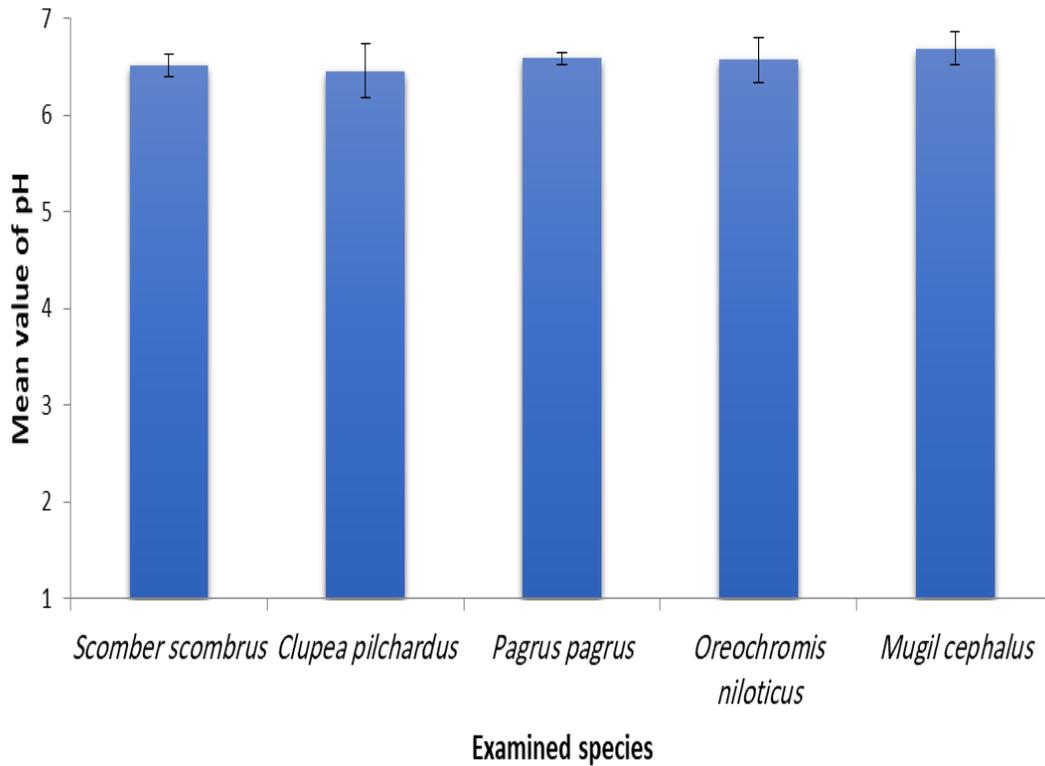
The results of bacterial counts, TVB-N, TBA, and histamine were analyzed using one-way ANOVA, followed by a post hoc Duncan's test to compare bacterial counts and chemical parameter values between different fish species (IBM SPSS Statistics, version 22). With a p value of 0.05, the test was significant. The APC, *S. aureus*, and Pseudomonas count data were reported as a log<sub>10</sub> standard deviation average (SD). While the data for TVBN, TBA, and histamine were reported as an average of value mean SD, the data for TVBN, TBA, and histamine were reported as an average of value mean SD.

### Results and discussion

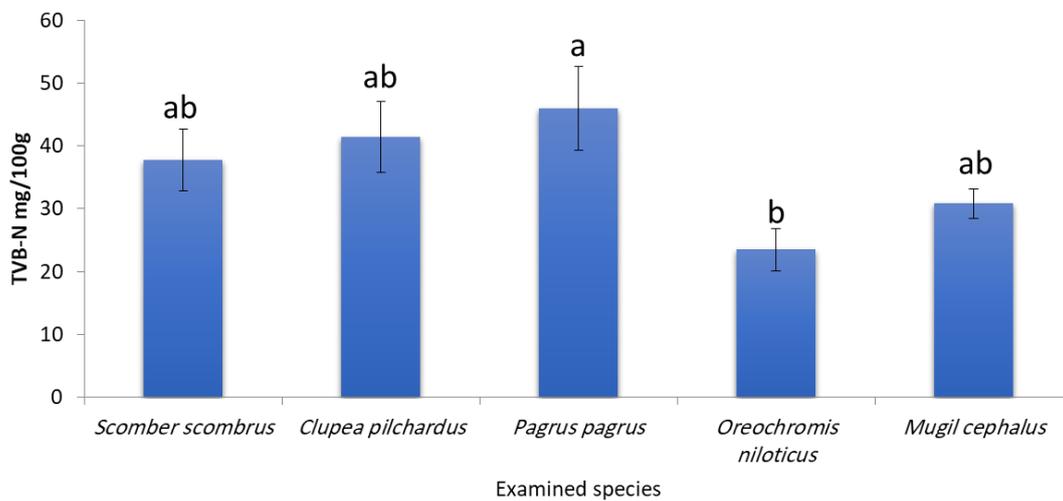
The natural pH in live fish is just above 7.0, typically about 7.3, but this value falls distinctly after death as the fish goes through rigor mortis and glycogen is converted into lactic acid. In most species, the postmortem pH is between 6.0 and 6.8 then rises again with spoilage [12]. The presented data in Figure 1 showed that pH mean values were  $6.52 \pm 0.11$ ,  $6.45 \pm 0.28$ ,  $6.58 \pm 0.06$ ,  $6.75 \pm 0.22$  and  $6.68 \pm 0.16$  in examined *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively. There were no

significant differences ( $P < 0.05$ ) between examined species attributed to the similarity in freezing condition. Freezing not only slows down the rate of bacterial growth but also the chemical changes responsible for quality deterioration [13]. The acceptability of examined fish according to the maximum permissible pH limit (6.5) of frozen fish established by Egyptian standard (ES) [14] was 70%, 80%, 45%, 70% and 65% of the examined *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus*, and *M. cephalus*, respectively (Table 1).

Total volatile basic nitrogen (TVB-N) is a key criterion for evaluating seafood quality and is one of the most common chemical indicators of marine fish deterioration. Inspectors must utilize TVB-N as a chemical check if the organoleptic test reveals any uncertainty about the freshness of fish according to a European Union directive on fish hygiene [15]. The level of TVB-N in descending manner was arranged as follow *P. pagrus*  $45.97 \pm 6.61 > C. pilchardus$   $41.41 \pm 5.62 > S. scombrus$   $37.75 \pm 4.79 > M. cephalus$   $30.82 \pm 4.32 > O. niloticus$   $23.5 \pm 3.35$  mg/100g (Figure 2). Nearly similar values for frozen fish 27-52 mg/100g was obtained by Jinadasa [16]. The *O. niloticus* was significantly lower ( $P < 0.05$ ) than other examined species, which may be due to low deteriorative changes as this type of fish stays for a short period in the distribution places, because it is a popular fish among the consumers. In the current study, the acceptability of frozen fish (Table 1) according to TVB-N content was 40%, 20%, 35%, 100% and 55% in *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively according to Egyptian standard (ES) [14], which established 30mg/100g as maximum permissible limit for TVB-N of frozen fish.



**Figure 1: Potency of hydrogen ions (pH) (Mean value ± SD) of examined frozen fish species.**



**Figure 2: Total volatile basic nitrogen (TVB-N) mg/100g (Mean value ± SD) of frozen fish species. Means of the same column carrying different superscript letters (a,b,c) are significantly different (P <0.05).**

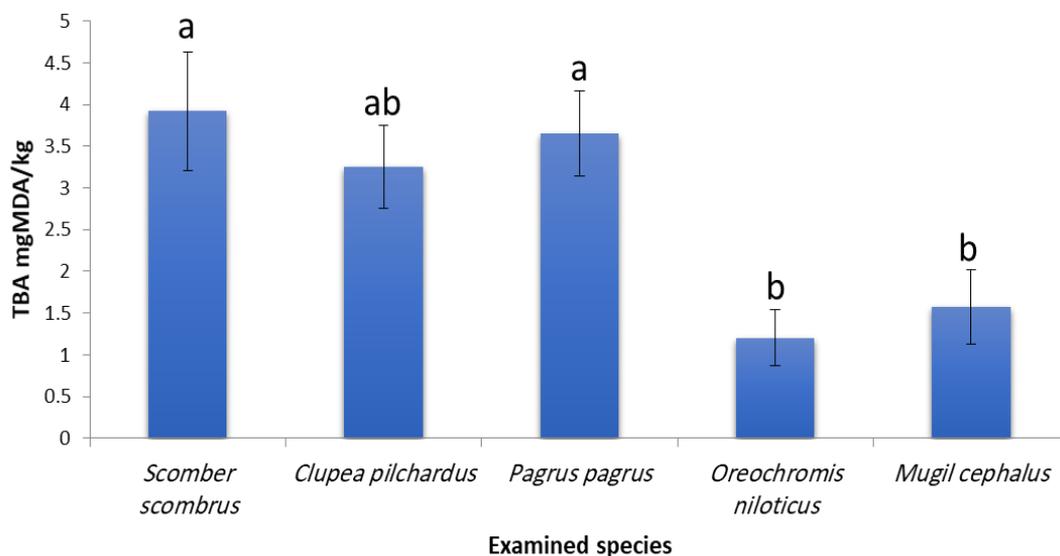
The TBA test is commonly used to determine lipid oxidation in food. Lipid oxidation is a major cause of food quality degradation and has long been a source of consternation for both manufacturers and food scientists. Because of the high vulnerability of

long-chain poly unsaturated fatty acid (PUFA) to oxidation and the significant requirement of these PUFA in fish diets, concerns regarding lipid oxidation have also been addressed in the aquaculture business [17]. In current study, Figure (3) showed that TBA value was

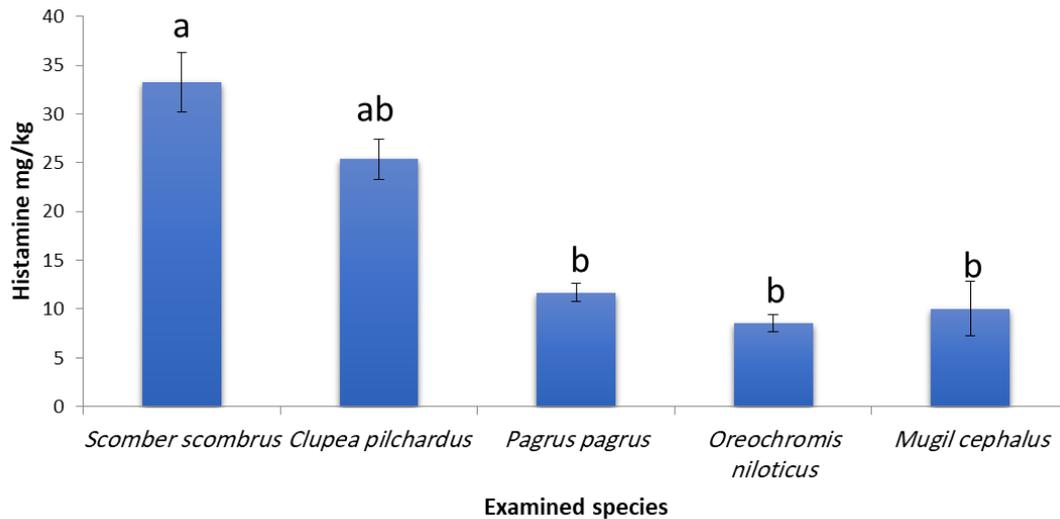
significantly higher ( $P < 0.05$ ) in *S. scombrus* ( $3.91 \pm 1.7$ mg MDA/kg) and *P. pagrus* ( $3.25 \pm 1.4$ mg MDA/kg) than *O. niloticus* ( $1.20 \pm 0.42$ mg MDA/kg) and *M. cephalus* ( $1.75 \pm 0.38$ mg MDA/kg). The differences may be attributed to the increase of oxidative deterioration in oily fish than other fishes in addition to the long period of freezing in retail outlets. A lower TBA value (0.30-1.06) was recorded in fish collected from Egyptian fish market [18]. The acceptability was 65%, 75%, 85%, 100%, and 100% for examined *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus*, and *M. cephalus*, respectively (Table 1). The Egyptian standard [14] declared that 4.5 mg MDA/kg fish flesh is usually considered the limit, beyond that frozen fish unfit for human consumption.

The amount of histamine in a sample indicates whether it is likely to spoil or cause scombroid toxicity. Histamine food poisoning can be caused by ingesting human to 100 mg/100 g of fish meat [19]. The Food and Drug Administration FDA has set a maximum acceptable level of 50 mg/kg for histamine [20]. In addition, Egyptian standard [14]

provide that the maximum permitted quantity of histamine for frozen fish, cannot exceed 100 mg/kg. The acceptability among examined samples was 100% according to the current Egyptian legislation (Table, 1). A maximum daily intake of histamine (50 mg) in meals has been published by the European Food Safety Agency for healthy adults [21]. The mean value of histamine was  $33.22 \pm 2.07$ ,  $25.35 \pm 3.09$ ,  $11.69 \pm 0.93$ ,  $8.56 \pm 0.91$  and  $10.02 \pm 0.76$ mg/kg in *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively. Higher histamine values of 206 – 230, 175 – 230, 125-237 and 89 – 97mg/kg were respectively recorded in *S. scombrus*, *C. pilchardus*, *P. pagrus*, and *O. niloticus* by Refai *et al.*, [22]. Histamine value in *S. scombrus* was significantly higher ( $P < 0.05$ ) than other examined species (Figure 4). These differences could have been caused by a higher concentration of the amino acid histidine, which is a precursor to histamine in the presence of bacterial carboxylation. This result was completely consistent with Kim *et al.*, [23], who reported that mackerel and tuna fish had higher levels of histidine.



**Figure 3: Thiobarbituric acid (TBA)mg Malondialdehyde (MDA) / kg (Mean value ± SD) of frozen fish species.** Means of the same column carrying different superscript letters (a,b,c) are significantly different ( $P < 0.05$ ).



**Figure 4: Histamine level mg/kg (Mean value  $\pm$  SD) of frozen fish species.** Means of the same column carrying different superscript letters(a,b,c) are significantly different ( $P < 0.05$ ).

The APC count in *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus* was  $6.11 \pm 0.56$ ,  $6.28 \pm 0.47$ ,  $7.23 \pm 0.69$ ,  $5.18 \pm 0.43$  and  $6.09 \pm 0.52$   $\log_{10}$  CFU/g, respectively as shown in Table 2. The obtained counts were comparable to APC count in fish samples from Spain  $5.27 \log_{10}$  CFU/g [24]. Also,  $5.7 \pm 2.1$ ,  $6.0 \pm 1.98$ ,  $7.2 \pm 2.96$ , and  $5.1 \pm 1.36$   $\log_{10}$  CFU/g in the examined *T. nilotica*, *M. cephalus*, *P. pagrus*, and *S. scombrus*, respectively in fish from Egypt [18]. Meanwhile, lower APC in Italy as 31% of examined raw fish presented an APC count in the range of  $10^3$ - $10^4$  CFU/g, 34% in the range of  $10^4$ - $10^5$  CFU/g, and 24% higher

than  $10^5$  CFU/g [25]. In comparison to the other fish species studied, the mean value of APC in *P. pagrus* was significantly higher ( $P < 0.05$ ), which may be due to the species' poorer marketability in Dakahlia fish markets, more time spent in contact with contaminated ice and utensils, and temperature fluctuations in retail establishments. The acceptability was 45%, 100% and 55% for examined *S. scombrus*, *O. niloticus* and *M. cephalus*, respectively. Meanwhile, all examined *C. pilchardus* and *P. pagrus* were rejected according to the APC when compared with the Egyptian standard [14].

**Table (1): Acceptability of the examined samples according their chemical parameters in relation to Egyptian standards of frozen fish (889-1/ 2005).**

Egyptian standard (889-1/ 2005)		<i>S. scombrus</i>	<i>C. pilchardus</i>	<i>P. pagrus</i>	<i>O. niloticus</i>	<i>M. cephalus</i>
<b>pH (6.5)</b>	within	14 (70%)	16 (80%)	9 (45%)	14 (70%)	13 (65%)
	exceeded	6 (30%)	4 (20%)	11 (55%)	6 (30%)	7 (35%)
<b>TVB-N (30mg/100g)</b>	within	8 (40%)	4 (20%)	7 (35%)	20 (100%)	11 (55%)
	exceeded	12 (60%)	16 (80%)	13 (65%)	-	9 (45%)
<b>TBA (4.5mg MDA/kg)</b>	within	13 (65%)	15 (75%)	17 (85%)	20 (100%)	20 (100%)
	exceeded	7 (35%)	5 (25%)	3 (15%)	-	-
<b>Histamine (100mg/kg)</b>	within	20 (100%)	20 (100%)	20 (100%)	20 (100%)	20 (100%)
	exceeded	-	-	-	-	-

*S. scombrus*: *Scomber scombrus*, *C. pilchardus*: *Clupea pilchardus*, *P. pagrus*: *Pagrus pagrus*, *O. niloticus*:

*Oreochromis niloticus*, *M. cephalus*: *Mugil cephalus* TVB-N: total volatile basic nitrogen, TBA: thiobarbituric acid

**Table (2): Statistical analytical results of bacterial counts log<sub>10</sub>CFU/g of examined frozen fish samples (n= 20 for each).**

Fish species	APC	<i>S. aureus</i>	<i>Pseudomonas</i>
	Min- Max Mean ± SD	Min- Max Mean ± SD	Min- Max Mean ± SD
<i>Scomber scombrus</i>	5.24 - 7.23 6.11 ± 0.56 <sup>b</sup>	<2- 4.22 3.24 ± 0.43 <sup>ab</sup>	2.68 - 3.95 3.31 ± 0.39 <sup>b</sup>
<i>Clupea pilchardus</i>	6.11 - 7.09 6.28 ± 0.47 <sup>ab</sup>	<2- 3.84 3.11 ± 0.39 <sup>ab</sup>	2.45- 3.69 2.98 ± 0.37 <sup>bc</sup>
<i>Pagrus pagrus</i>	6.54 - 7.98 7.23 ± 0.69 <sup>a</sup>	<2- 4.56 3.81 ± 0.49 <sup>a</sup>	3.42- 5.11 4.29 ± 0.51 <sup>a</sup>
<i>Oreochromis niloticus</i>	4.28 - 5.61 5.18 ± 0.43 <sup>c</sup>	<2- 3.22 2.57 ± 0.41 <sup>b</sup>	2.16 - 3.44 2.45 ± 0.32 <sup>c</sup>
<i>Mugil cephalus</i>	5.36 - 6.64 6.09 ± 0.52 <sup>b</sup>	<2- 4.08 3.16 ± 0.44 <sup>ab</sup>	2.54- 3.95 3.34 ± 0.38 <sup>b</sup>

Means of the same column carrying different superscript letters (a,b,c) are significantly different (P <0.05). APC: aerobic plate count, *S. aureus*: *Staphylococcus aureus*, Min: Minimum, Max: Maximum, SD: standard deviation

Microorganisms of the genus *S. aureus* are found in the environment and are linked to human sources. As a result, the count of *S. aureus* is regarded as a crucial indicator of fish processing sanitation [26]. The *S. aureus* count was 3.24 ± 0.43, 3.11 ± 0.39, 3.81 ± 0.49, 2.57 ± 0.41, 3.16 ± 0.44 log<sub>10</sub> CFU/g in examined *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively as shown in Table 2. Nearly similar counts were obtained in Spain as 3 log<sub>10</sub> CFU/g [24] and in Egypt from 2-4 log<sub>10</sub> CFU/g [18]. On contrary, *S. aureus* was not detected in fish samples collected from Italy [25]. The results in Table (3) declared that the acceptability was 60%,

70%, 35%, 85% and 40% for examined *S. scombrus*, *C. pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively according to the Egyptian standard [14] which established that 3 log<sub>10</sub>CFU/g of fish flesh is usually considered the limit, beyond that frozen fish unfit for human consumption. The *S. aureus* count was significantly lower in examined *O. niloticus*, which may be attributed to the higher rate of selling than other species that decrease the chance of handling and contamination. Additionally, *O. niloticus* freshwater fish habitat and *Staphylococcus* species grows at optimum conditions (3.5% NaCl and 37°C) [27].

**Table (3): Acceptability of the examined samples according their bacteriological parameters in relation to Egyptian standards of frozen fish (889-1/ 2005).**

Egyptian standard (889-1/ 2005)		<i>S. scombrus</i>	<i>C. pilchardus</i>	<i>P. pagrus</i>	<i>O. niloticus</i>	<i>M. cephalus</i>
APC (6 log <sub>10</sub> CFU/g)	within	9 (45%)	-	-	20 (100%)	11 (55%)
	exceeded	11 (55%)	20 (100%)	20 (100%)	-	9 (45%)
<i>S. aureus</i> (3 log <sub>10</sub> CFU/g)	within	12 (60%)	14 (70%)	7 (35%)	17 (85%)	8 (40%)
	exceeded	8 (40%)	6 (30%)	13 (65%)	3 (15%)	12 (60%)

APC: aerobic plate count, *S. aureus*: *Staphylococcus aureus*

Pseudomonads are a good spoilage index in fishes and a marker for fish deterioration. Furthermore, they have to be the specific spoilage organism (SSO) in ice-stored freshwater fish. Additionally, the microbial population of fish stored aerobically under

chilling condition consists almost exclusively of *Pseudomonas* spp..[28]. Data in Table 2 showed that the mean standard deviation of *Pseudomonas* spp. count was 3.31 ± 0.39, 2.98 ± 0.37, 4.29 ± 0.51, 2.45 ± 0.32, 3.34 ± 0.38 log<sub>10</sub> CFU/g in examined *S. scombrus*, *C.*

*pilchardus*, *P. pagrus*, *O. niloticus* and *M. cephalus*, respectively. Nearly similar counts were obtained in fish by Angis and Oğuzhan [29], Badee *et al.*, [30], Li *et al.*, [31] and Hussein *et al.*, [18]. Meanwhile, lower count obtained by Khalafalla *et al.*, [12]. The *P. pagrus* contained significantly higher *Pseudomonas* count ( $P < 0.05$ ), which may be attributed to lower marketability and long time in retail outlet that enhance growth and multiplication of *Pseudomonas* spp. No available regulation for *Pseudomonad* count in fish.

### Conclusion

The current study declared that examined fish harbored *S. aureus* and *Pseudomonas*, which may induce public health hazard to consumers in addition to some samples have high level of total volatile basic nitrogen and thiobarbituric acid than the recommended level indicating the lower nutritional quality. The level of histamine in the examined fish is below the public health hazard or toxicity limits.

### Conflict of Interest

The authors have no conflict of interest to declare.

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### الملخص العربي

#### مقاييس الجودة لبعض الأسماك المجمدة المسوقة بمحافظة الدقهلية

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تدهور حالة الأسماك مباشرة بعد الصيد والتخزين وأثناء البيع بالتجزئة. في هذه الدراسة تم تجميع مائة عينة من الماكريل، السردين، المرجان، البلطي والبوري (20)، لكل منها) جمعت عشوائياً من أسواق الأسماك المختلفة بمحافظة الدقهلية، مصر. فحص أسماك الماكريل تبين أن متوسطات الأس الهيدروجيني وإجمالي النيتروجين المتطاير وحمض الثيوباربيتوريك  $0.11 \pm 6.52$  و  $4.79 \pm 37.75$  و  $1.7 \pm 3.91$  على التوالي؛ في السردين كانت المتوسطات  $6.45 \pm 0.28$ ،  $41.41 \pm 5.62$  و  $1.24 \pm 3.25$ ، في المرجان  $0.06 \pm 6.58$ ،  $6.61 \pm 45.97$  و  $1.4 \pm 3.25$ ؛ في البلطي  $0.22 \pm 6.75$ ،  $3.35 \pm 23.5$  و  $0.42 \pm 1.20$  وفي البوري  $0.16 \pm 6.68$ ،  $4.32 \pm 30.82$  و  $0.38 \pm 1.75$  على التوالي. وكانت قيمة الهستامين في الماكريل أعلى معنوياً ( $P < 0.05$ ) من الأنواع المفحوصة ولكن جميع العينات المفحوصة ضمن الحد المسموح به. احتوت أنواع المرجان على أعلى أعداد للميكروبات الهوائية، المكور العنقودي الذهبي والسيدوموناس مقارنة بالأنواع الأخرى التي تم فحصها. ووجد أن أسماك البلطي المفحوصة احتوت على أقل تعداد جرثومي وتغيرات كيميائية وهستامين. وجد أن الأسماك المجمدة التي تم فحصها ملوثة بالمكور العنقودي الذهبي والسيدوموناس إضافة لأحتوائها على كميات من النيتروجين المتطاير وحمض الثيوباربيتريك أعلى من الحدود المسموح بها في المواصفات القياسية المصرية. وتبين أن نسب الهستامين في جميع العينات التي تم فحصها أقل من المستوى الذي يمكن أن يؤدي إلى حدوث مشاكل صحية أو تسمم.