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MICROBIOLOGICAL AND PHYSICOCHEMICAL QUALITY OF SALTED BLUESPOT MULLET (*VALAMUGIL SEHELI*) STORED AT DIFFERENT TEMPERATURE

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ABSTRACT

Changes in the microbiological and physicochemical quality of salted wild mullet (*Valamugil seheli*) stored at ambient temperature ($22 \pm 1°C$) and refrigerator ($4 \pm 1°C$) for 180 days were investigated. The total mesophilic viable counts in salted fish stored at ambient temperature and at refrigerator ranged from 2.04 ± 0.08 to 4.15 ± 0.06 log cfu/g^{-1}, and from 3.62 ± 0.39 to 4.52 ± 0.50 log cfu/g^{-1}, respectively. Populations of psychrotrophic viable bacteria in salted fish stored at ambient temperature and at refrigerator ranged from 2.51 ± 0.13 to 4.08 ± 0.04 log cfu/g^{-1}, and from 3.43 ± 0.34 to 4.49 ± 0.52 log cfu/g^{-1}, respectively. The total mesophilic and psychrotrophic viable counts in salted fish stored at ambient temperature and at refrigerator were significantly decreased ($P < 0.05$) gradually throughout the storage period. Moreover, none of the salted mullet samples harbored coliform including *Escherichia coli*.

The salt, pH, water activity (A_w) moisture, protein, lipid and ash values of salted fish stored at ambient temperature ranged from 20.3 to 23.2%, 5.6 to 6.2, 0.283 to 0.755, 10.3 to 44.5, 23.1 to 56.1, 4.5 to 17.0 and 19.0 to 23.9, respectively, whereas the corresponding values of salted fish stored at refrigerator ranged from 18.0 to 23.2%, 5.1 to 6.5, 0.730 to 0.755, 33.0 to 44.5, 23.1 to 40.1, 4.5 to 5.8 and 19.0 to 21.9, respectively.

The total volatile basic nitrogen value of salted fish stored at ambient temperature and at refrigerator ranged from 34.5 to 57.4 and 34.5 to 51.8 mg/100 g, respectively.

The histamine value of salted fish stored at ambient temperature and at refrigerator ranged from 16.0 to 18.0 and from 16.0 to 18.6 mg/100 g, respectively.

PRACTICAL APPLICATIONS

Salting is one of the oldest and most common methods that have been used worldwide for fish preservation. This study aimed to determine the microbiological and physicochemical quality of salted bluespot mullet (*Valamugil seheli*) during refrigerated storage ($4 \pm 1°C$) and at ambient temperature ($22 \pm 1°C$). The results obtained from this study demonstrated that the salted mullet had high levels of total volatile basic nitrogen and histamine. Therefore, the results of this study would be useful for the scientific community and can be utilized by researches in future studies as well as by manufacturers to develop better processing and preservation strategy for salted fish.

INTRODUCTION

Bluespot mullet (*Valamugil seheli*) is a fish belonging to the Mugilidae family, and found worldwide in coastal temperate and tropical water. The mullets are of considerable importance in the capture and culture fisheries in many parts of the world and demand has increased during the last decade. In Saudi Arabia, mullet is one of the traditional and popular foods, and a large proportion has been used almost

exclusively for fresh consumption and the remained part is processed into salted product.

Fish and shellfish products are a rich source of many important nutritional compounds such as high- quality protein, vitamins, minerals and *n*-3 rich polyunsaturated fatty acids. There is an increasing world demand for fish and other seafood products. However, seafood including finfish and shellfish are classified as one of the most highly perishable food products than other muscle foods, due to their high water activity (A_w), neutral pH value, and presence of autolytic enzymes, which causes the rapid development of undesirable odors and flavors (Ashie *et al.* 1996; Dalgaard *et al.* 2006).

The quality of fish and fish products degrades because both chemical reactions and microbial growth occur during handling and storage (Gram and Huss 1996). Therefore, on fishing, the process of preservation is required to prevent fish spoilage and extend the shelf life without affecting its quality and nutritional (Ghaly *et al.* 2010). Preservation techniques are frequently used in seafood processing, transportation and storage to prevent the growth and survival of pathogenic and spoilage microorganisms. A number of preservation techniques were described for fish preservation such as salting, drying, smoking, chilling, freezing, fermentation and canning. They are designed to inhibit the activity of spoilage bacteria and the metabolic changes that result in the loss of fish quality. Historically, salting is one of the oldest techniques that have been used worldwide for fish preservation, and is essentially intended to prevent spoilage and to extend the shelf life of seafood. In addition, Salting process is still widely applied around the world and a highly appreciated product due to its high demand and simplicity of processing (Ghaly *et al.* 2010). Salting is performed either by dry-salting, wet-salting, brine-salting, brine injection or a combination of these methods. Salt uptake depends on many factors including species, fish size, weight, muscle thickness, muscle characteristic, composition (lipid content and distribution), physiological state, salting method, brine concentration, brining time, fish to salt ratio ambient temperature and freezing and thawing (Ismail and Wootton 1992; Wang *et al.* 2000; Jittinandana *et al.* 2002; Gallart-Jornet *et al.* 2007).

Salted fish, especially mullet is a widely valued fish species that is consumed in many Asian and African countries (Basti *et al.* 2006; Kung *et al.* 2008; Rabie *et al.* 2009), due to its particular flavor and texture. To our knowledge, no data are available about the bacterial load and physicochemical in salted wild bluespot mullet (*V. seheli*). Therefore, the objective of this study was to investigate the microbiological and physicochemical quality of dry salted wild bluespot mullet (*V. seheli*) during storage at refrigerated and ambient temperature.

MATERIALS AND METHODS

Samples Collection, Preparation and Storage

Twenty one of dry salted wild mullet (*V. seheli*) with an average weight of 560 ± 12.86 g were purchased from a local fish market in Riyadh. The fish were transported to the laboratory within 30 min. On arrival in the laboratory, immediately three whole fish were randomly selected before packaging for microbiological and physicochemical analysis, and the rest of the fish were wrapped individually in septic bags and divided equally into two lots. One lot was stored at ambient temperature (22 ± 1°C) and the other lot was refrigerated (4 ± 1°C) for up to 180 days. Sampling was performed at predetermined time intervals namely: 0, 60, 120 and 180 days. At each sampling day three fish from each lot were randomly chosen for microbiological and physicochemical analysis.

Microbiological Analysis

A 25 g portion of salted mullet was taken aseptically, and homogenized for 60 s in homogenizer (PRO Scientific Inc. Model PRO400) with 225 mL sterilized physiological saline of NaCl 0.85% (w/v) containing 0.1% peptone (Oxoid, Basingstoke, UK). The homogenates were serially diluted with a sterile phosphate buffer, and 0.1 mL aliquots of the dilutes were inoculated in duplicate into the surface of tryptone soya agar (TSA; Oxoid, Basingstoke, UK) plates, containing 1% NaCl. The plates were incubated aerobically at 10°C for 10 days for the enumeration of the total psychrotrophic bacteria counts and for 3 days at 30°C for the enumeration of the total mesophilic bacterial counts.

Analyses of total and fecal coliforms in salted wild mullet were enumerated using the most probable number technique based on the procedure described by the Association of Official Analytical Chemists (AOAC 2000).

The numbers of viable colonies were counted using a Quebec Darkfield Colony Counter (Leica, Buffalo, NY) equipped with a guide plate ruled in square centimeters. Reading obtained with ≥30–300 colonies on plate were used to calculate bacterial population results, expressed as logarithm of colony forming units ($\log_{10}$ cfu) per gram of sample.

Chemical Analysis

Proximate Composition. Proximate analyses (the moisture content, total crude protein, ash content and lipid content) of the fish muscle were based on the procedures set by AOAC (2000). Moisture content was determined by oven drying of 5 g of minced muscle at 80°C for 24 h to constant weight ($n = 3$). Protein content of the fish samples was

determined by Kjeltec auto sampler system 1035 Analyzer. About 0.5 g of minced fish placed in long necked Kjeldahl digestion flask, with two catalyst tablets (each containing 0.4 g $CuSO_4$ and 3.5 g K_2SO_4). After that, 12 mL of concentrated sulphuric acid (H_2SO_4) were added to the flask; next, flask was heated for approximately 2 h at 420°C (1 h after contents are clear). After digestion, the flask was cooled and 50 mL of distilled water was added to the flask. The flask was placed in Kjeltec auto sampler 1035 system where the ammonia is distilled into boric acid and the acid is simultaneously titrated with diluted sulphuric acid. The nitrogen content was multiplied by 6.25 to get the protein (ISO 1997).

Ash contents were determined by ashing of 2 g of minced fish in a furnace at 500°C–550°C for 24 h. Lipid content was determined by Soxhlet extraction with petroleum ether after acid hydrolysis (Soxtherm; Gerhardt GmbH & Co. KG, Germany). A dray extraction beaker glass was accurately weighed; 2 g of the sample was placed in a Whatman cellulose extraction thimble. The sample in the thimble was covered with cotton wool then placed in the pre-weighed extraction beaker glass, which was placed into a soxlet apparatus (lipid extraction unit). Lipid was extracted in the Soxtec system with 120 mL of diethyl ether for 6 h. Finally, the ether was evaporated off and the beaker class dried in an oven at (100°C) for 30 min and was cooled in a desiccator. The weight increase of the flask corresponded to the lipid content.

Chemical Indices [Determination of pH Value, Salt Content and Water Activity (A_w)]. The pH of the samples was determined on homogeneous mixture of salted mullet muscle and distilled water (1:10, w : v) using a digital pH-meter (WTW Multiline P4, Wissenschaftlich-Technische Werkstätten GmbH, Weilheim, Germany). Salt content of the mullet muscle samples was determined according to the AOAC procedure (AOAC 2000). Briefly, 1 g of mullet muscle was treated with 10 mL of 0.1 M $AgNO_3$ and 10 mL of HNO_3. The homogenate was heated gently on a hot plate for 10 min. The homogenate was then cooled with running water. Then 50 mL of distilled water and 5 mL of ferric alum indicator were added, followed by titration with standard 0.1 M KSCN until the solution became permanent brownish-red. The salt content was then calculated and expressed as % NaCl. Water activity (A_w) values were determined at 25°C using an AquaLab CX-2 water activity meter (Decagon Devices, Inc., Pullman, WA).

Determination of Total Volatile Basic Nitrogen. Total volatile basic nitrogen (TVB-N) values were determined by steam distillation according to the method described by Antonacopoulos and Vyncke (1989) by using steam distillation apparatus, with drag steam. Briefly, 10 g of mullet muscle was homogenized with 250 mL of distilled water and stirred for 30 min. The mixture was distilled after the addition of 2 g of magnesium oxide, boiling beads and one drop of silicone to prevent foaming. The distillate was collected for 30 min in a flask containing 20 mL of 2% (w/v) boric acid and a few drops of modified methyl red. The distillate was titrated with 0.1 N sulphuric acid (H_2SO_4) solution, and the TVB-N value was expressed as mg TVB-N/100 g fish muscle.

Determination of Histamine. Histamine was determined by a simple and rapid method for colorimetric test using assay kit HisQuick (LDN GmbH & Co. KG, Nordhorn, Germany). Fish samples (2 g) were homogenized with 20 mL of 70% isopropanol solution then shaken vigorously for 4 min by shaker. The extract was filtered through a filter paper (Whatman No.1 filter) and the solids were settled down for a few minutes. The supernatant is applied to the extraction column. Each extraction column was washed with 2 mL of Wash Buffer which was prepared early, 200 μL of the supernatant was added onto the extraction columns until the extract was surged into the extraction columns, then the extraction columns was washed with 1 mL 70% isopropanol solution, after that washed 2 times with 3 mL wash buffer which was prepared early. The passed through wash buffer was discarded and test tubes used to collect the eluates. A 0.5 mL of elution buffer was pipetted carefully onto extraction columns until it surged into the extraction columns then 0.5 mL of elution buffer was pipetted again into the extraction columns, next, both eluates was collected and mixed in the same test-tube, 200 μL was used for the subsequent histamine measurement. Fifty microliter each of the standard A-F was pipetted into the microtiter plate and 150 μL of elution buffer were pipetted to each standard well, 200 μL each of the extracted samples was pipetted into the microtiter plate, and then 50 μL of the color reagent solution which was prepared before was pipetted to each well and mixed. After 2 min the absorbance of the solution in the wells was read using a microplate reader (450 nm).

Statistical Analysis

The significance of differences between means ($P < 0.05$) for the bacterial and chemical results was analyzed using one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Microbiological Analyses

The changes in mesophilic and psychrotrophic bacterial counts of salted wild mullet (*V. seheli*) during storage at ambient temperature and at refrigerator at various time

TABLE 1. TOTAL VIABLE COUNTS (LOG_{10} CFU/G) IN SALTED FISH STORED AT AMBIENT TEMPERATURE AND AT REFRIGERATOR

	Fish stored at ambient temperature		Fish stored at refrigerator	
Time (Days)	Mesophilic	Psychrotrophic	Mesophilic	Psychrotrophic
0	4.15 ± 0.06aA	4.08 ± 0.04aA	4.15 ± 0.06aA	4.08 ± 0.04aA
60	2.93 ± 0.11bA	2.51 ± 0.13bA	4.52 ± 0.50aA	4.49 ± 0.52aA
120	2.28 ± 0.12cB	NDcA	3.88 ± 0.52aA	3.82 ± 0.46aA
180	2.04 ± 0.08dB	NDdA	3.62 ± 0.39aA	3.43 ± 0.34aA

Each value is a mean ± SD of three replicate samples; Different lowercase letters in each column characterize or uppercase letters characterize between rows are statistically significant (One-way ANOVA test $P < 0.05$ and subsequent post hoc multiple comparisons with Scheffe test). ND, not detected.

intervals are summarized in Table 1. The initial mesophilic and psychrotrophic counts in salted fish were 4.15 ± 0.06 and 4.08 ± 0.04 log cfu/g^{-1}, respectively. During the period of study, the total mesophilic and psychrotrophic viable counts in salted fish stored at ambient temperature ranged from 2.04 ± 0.08 to 4.15 ± 0.06 log cfu/g^{-1}, and from 2.51 ± 0.13 to 4.08 ± 0.04 log cfu/g^{-1}, respectively (Table 1). The total mesophilic and psychrotrophic viable counts in salted fish stored at refrigerator ranged from 3.62 ± 0.39 to 4.52 ± 0.50 log cfu/g^{-1} and from 3.43 ± 0.34 to 4.49 ± 0.52 log cfu/g^{-1}, respectively, (Table 1). Patir *et al.* (2006) reported that the total mesophilic aerobic bacterial counts in salted grey mullet (*Chalcalburnus tarichii*) stored at 4 ± 1°C ranged from 2.0 to 5.0 log cfu/g^{-1}, with average 3.94 log cfu/g^{-1}. The total mesophilic and psychrotrophic viable counts in salted mullet stored at refrigerator was significantly ($P < 0.05$) higher than in salted mullet stored at ambient temperature. Similar results were reported by Karacam *et al.* (2002) in brined anchovies (*Engraulis encrasicolus*). Inhibition of bacterial growth could be related to the water activity (A_w) value and the moisture content which found to be much lower in the salted fish stored at ambient temperature than in the salted fish stored at refrigerator.

In general, the bacterial load was significantly decreased ($P < 0.05$) gradually with time of storage for all treatment. A comparable pattern of the decrease in mesophilic and psychrotrophic bacteria has been reported in brined anchovies stored at ambient temperature and at refrigerator (Karacam *et al.* 2002). In this study, a complete inhibition on the growth of psychrotrophic bacteria was achieved by day 120 in salted mullet stored at ambient temperature. Hernandez-Herrero *et al.* (2002) reported a gradual decrease in the psychrotrophic bacteria count during 9-week ripening of salted anchovies (*E. encrasicholus*) kept in plastic cans at 20°C. The results obtained suggest that the bacteria counted might be inhibited or killed due to the effect of the temperature, moisture, water activity and storage period.

Moreover, no coliform and *E. coli* were isolated from salted mullet stored at ambient temperature and at refrigerator. These results are in general agreement with those previously reported by Hwang *et al.* (2012) for salted escolar roe products, Kung *et al.* (2008) for salted mullet roe products, Lin *et al.* (2012) for salted seafood products and Tsai *et al.* (2007) for dried milkfish (*Chanos chanos*). The higher salt contents in these salted mullet muscle samples apparently had inhibitory impact on coliform including *E. coli* growth. Wheaton and Lawson (1985) reported that the bacteria associated with seafood spoilage were increasingly stressed when the salt content in fish increased above 1%. Higher salt contents (>5.0%) in salted mackerel (*Scomber australasicus*), apparently had some inhibitory effect on bacterial growth (Tsai *et al.* 2005). In contrast, Patir *et al.* (2006) reported that the coliform bacteria in salted grey mullet (*C. tarichii*) ranged from <1.0 to 4.03 log cfu/g^{-1} with average 3.20 log cfu/g^{-1}.

Chemical Analyses

The chemical compositions during the 180 days of storage period for salted fish stored at ambient temperature and at refrigerator are given in Tables 2–5.

Proximate Composition

Changes in the moisture, protein, lipid and ash content of salted fish stored at ambient temperature and at refrigerator are shown in Tables 2 and 3. The moisture, protein, lipid and ash content of salted fish stored at ambient temperature ranged from 10.3 to 44.5, 23.1 to 56.1, 4.5 to 17.0 and 19.0 to 23.9, respectively, while the corresponding values of salted

TABLE 2. MOISTURE, PROTEIN, LIPIDS AND ASH IN SALTED FISH STORED AT AMBIENT TEMPERATURE

Time (Days)	Moisture	Protein	Lipid	Ash
0	44.5 ± 0.10a	23.1 ± 1.15a	4.5 ± 0.10a	19.0 ± 2.23a
60	31.8 ± 3.72b	34.8 ± 3.05b	9.2 ± 1.3a	21.0 ± 1.64a
120	10.3 ± 0.50bc	46.7 ± 2.40c	13.8 ± 2.30ab	23.9 ± 1.10ab
180	NA	56.1 ± 5.30cd	17.0 ± 2.20ac	NA

Each value is a mean ± SD of three replicate samples; Different lowercase letters in each column characterize or uppercase letters characterize between rows are statistically significant (One-way ANOVA test $P < 0.05$ and subsequent post hoc multiple comparisons with Scheffe test). NA, not analyzed due to limitation in sample amount.

TABLE 3. MOISTURE, PROTEIN, LIPIDS AND ASH IN SALTED FISH STORED AT REFRIGERATOR

Time (Days)	Moisture	Protein	Lipid	Ash
0	44.5 ± 0.10a	23.1 ± 1.15a	4.5 ± 0.10a	19.0 ± 2.23a
60	42.1 ± 2.00a	26.6 ± 2.60a	5.0 ± 0.61a	20.4 ± 1.57a
120	39.5 ± 1.64a	27.8 ± 2.10a	5.4 ± 0.30a	20.8 ± 2.20a
180	33.0 ± 2.46b	40.1 ± 4.80ab	5.8 ± 0.10b	21.9 ± 1.60a

Each value is a mean ± SD of three replicate samples; Different lowercase letters in each column characterize or uppercase letters characterize between rows are statistically significant (One-way ANOVA test $P < 0.05$ and subsequent post hoc multiple comparisons with Scheffe test).

fish stored at refrigerator was varied from 33.0 to 44.5, 23.1 to 40.1, 4.5 to 5.8 and 19.0 to 21.9, respectively. At the end of storage lipid and protein content were found to be much higher in the salted fish stored at ambient temperature than in the salted fish stored at refrigerator. On the contrary, moisture content was found to be much lower in the salted fish stored at ambient temperature than in the salted fish stored at refrigerator.

The moisture values measured in this study was close to the values (15.60–55.09) with mean value (42.96) reported by Patir *et al.* (2006) for salted grey mullet (*C. tarichii*).

The protein content measured in this study was lower than the 64.10–65.5% reported by El-Sebaiy and Metwalli (1989) for salted fermented mullet (*Mugil cephalus*). Meanwhile, the lipid content in this study was higher than the 2.21% reported by Hedayatifard and Yousefian (2010) for salted golden mullet (*Liza aurata*). No significant ($P < 0.05$) difference was observed in ash content among the salted fish stored at ambient temperature and the salted fish stored at refrigerator. A comparable pattern of ash content has been reported in salted fermented mullet (*M. cephalus*) (El-Sebaiy and Metwalli 1989).

Chemical Indices

Changes in the salt, water activity (A_w) and pH values of the salted mullet stored at ambient temperature and at refrigerator are shown in Tables 4 and 5, respectively. The salt, pH, water activity (A_w) value of salted fish stored at ambient temperature ranged from 20.3 to 23.2%, 5.6 to 6.2, 0.283 to 0.755, respectively, whereas the corresponding values of salted fish stored at refrigerator ranged from 18.0 to 23.2%, 5.1 to 6.5, 0.730 to 0.755, respectively. The pH values of both treatments were almost similar. These results on pH values are in agreement with those of previously reported by Tsai *et al.* (2005) for salted mackerel (*S. australasicus*), and by Patir *et al.* (2006) for salted grey mullet (*C. tarichii*). The salt content was nearly similar between the salted fish stored at ambient temperature and at refrigerator. In most cases, the salt content was high in both treatments, salted fish stored at ambient temperature and at refrigerator. The salt content measured in this study are higher than the (2.1–10.2%) reported by Kouakou *et al.* (2012) in Ivorian traditional salted fermented fish, but are nearly close to the values (17.0–32.87%) with mean value (24.63%) reported by Patir *et al.* (2006) for salted grey mullet (*C. tarichii*).

The water activity (A_w) value of salted fish stored at ambient temperature decreased gradually with time of storage, while in salted fish stored at refrigerator remained almost constant. The water activity (A_w) values were usually found to be below 0.8 might be due to effect of salt which generally eliminates the water from the fish muscle. Lin *et al.* (2012) reported that the water activity (A_w) for salted fish products ranged from 0.73 to 0.86.

Total Volatile Basic Nitrogen

Changes in the TVB-N of the salted fish during storage at ambient temperature and at refrigerator are shown in Tables 4 and 5. The initial TVB-N values of salted fish samples on day 0 (34.5 mg/100 g). The TVB-N value of salted fish stored at ambient temperature and at refrigerator ranged from 34.5 to 57.4 and from 34.5 to 51.8 mg/100 g, respectively. This result of TVB-N value was lower than previously reported by Lin *et al.* (2012) for salted fish product stored at ambient temperature (21.9–182.0 mg/100 g) with average level (99. 0 mg/100 g) and by Kuda *et al.* (2007) for salted and fermented fish products in Japan (41–136 mg/100 g), but was higher than previous report by Gümüş *et al.* (2008) in vacuum packaged salted red mullet (*Mullus barbatus*) stored at 4°C (17.08–36.36 mg/100 g). A comparable pattern of the increase in TVB-N (35.70–88.20 mg/100 g) with mean value

TABLE 4. SALT, WATER ACTIVITY, pH, TOTAL VOLATILE BASIC NITROGEN AND HISTAMINE IN SALTED FISH STORED AT AMBIENT TEMPERATURE

Time (Days)	Salt	(A_w)	pH	TVB-N	Histamine
0	23.2 ± 0.51%	0.755 ± 0.015a	6.1 ± 0.15a	34.5 ± 1.90a	16.0 ± 0.96a
60	20.7 ± 0.95%	0.742 ± 0.007a	6.2 ± 0.17a	50.7 ± 2.65b	17.1 ± 0.98a
120	20.3 ± 1.15%	0.642 ± 0.011b	6.0 ± 0.15ab	57.4 ± 2.70bc	18.0 ± 0.79a
180	22.9 ± 0.15%	0.283 ± 0.009c	5.6 ± 0.06b	51.8 ± 3.10cd	NA

Each value is a mean ± SD of three replicate samples; Different lowercase letters in each column characterize or uppercase letters characterize between rows are statistically significant (One-way ANOVA test $P < 0.05$ and subsequent post hoc multiple comparisons with Scheffe test). NA, not analyzed due to limitation in sample amount.

TABLE 5. SALT, WATER ACTIVITY, PH, TOTAL VOLATILE BASIC NITROGEN AND HISTAMINE IN SALTED FISH STORED AT REFRIGERATOR

Time (Days)	Salt	(A_w)	pH	TVB-N	Histamine
0	23.2 ± 0.51%	0.755 ± 0.015a	6.1 ± 0.15a	34.5 ± 1.90a	16.0 ± 0.96a
60	18.2 ± 0.95%	0.752 ± 0.009a	6.3 ± 0.15a	38.5 ± 1.54a	16.9 ± 1.60a
120	18.0 ± 1.50%	0.751 ± 0.003a	6.5 ± 0.10ab	42.9 ± 4.40a	18.6 ± 1.11a
180	21.0 ± 1.90%	0.730 ± 0.007a	5.1 ± 0.06a	51.8 ± 3.10b	NA

Each value is a mean ± SD of three replicate samples; Different lowercase letters in each column characterize or uppercase letters characterize between rows are statistically significant (One-way ANOVA test $P < 0.05$ and subsequent post hoc multiple comparisons with Scheffe test). NA, not analyzed due to limitation in sample amount.

(55.40) has been reported by Patir *et al.* (2006) for salted grey mullet (*C. tarichii*).

In this study, the TVB-N value of salted fish stored at ambient temperature was significantly ($P < 0.05$) higher than in salted mullet stored at refrigerator. In general, the TVB-N value of salted fish stored at ambient temperature and at refrigerator increased progressively with time of storage. Its increase in fish during storage is related to the bacterial spoilage and activity of endogenous enzymes (Kyrana *et al.* 1997; Vareltzis *et al.* 1997; Chomnawang *et al.* 2007). The increase of TVB-N value has been previously reported in brined anchovies stored at ambient temperature and at refrigerator (Karaçam *et al.* 2002), vacuum packaged salted red mullet (*M. barbatus*) stored at 4°C (Gümüş *et al.* 2008) and salted seafood products stored at ambient temperature (Lin *et al.* 2012).

Total volatile basic nitrogen (TVB-N) is one of the most widely traditional chemical used parameter for evaluation of the degree of spoilage in seafood. Several authors have been reported different acceptability levels for TVB-N value: 35–40 mg/100 g (Connell 1990); 25–30 mg/100 g (Lopez-Caballero *et al.* 2000); 20–25 mg/100 g (Kim *et al.* 2002). In this study, the TVB-N values of salted fish samples exceeded the above limit of 35 mg/100 g approximately 60 days of storage (50.7 mg/100 g of salted fish stored at ambient temperature), and (38.5 mg/100 g of salted fish stored at refrigerator).

Histamine

Changes in the histamine of the salted fish during storage at ambient temperature and at refrigerator are shown in Tables 4 and 5. The initial histamine value of salted fish samples was 16.0 mg/100 g. The histamine value of salted fish stored at ambient temperature was varied from 16.0 mg/100 g to 18.0 mg/100 g, while the value of salted fish stored at refrigerator was varied from 16.0 mg/100 g to 18.6 mg/100 g. The histamine value of salted fish stored at ambient temperature and at refrigerator increased progressively with time of storage. In this study, the initial content of histamine in salted fish were significantly higher ($P < 0.05$) than 5.0 mg/100 g, the allowable histamine limit suggested by the US Food and Drug Administration (FDA) for scombroid fish/or product (USFDA 2001). The result of histamine was higher than that reported in salted grey mullet (Kung *et al.* 2008). However, high content of histamine were frequently detected in salted and fermented anchovy (Mah *et al.* 2002), in salted and fermented mackerel and sardine products (Kuda *et al.* 2007) and in salted fermented fish (Feseekh) (Rabie *et al.* 2009). High levels of histamine in foods can have important vasoactive effects in humans (Lehane and Olley 2000).

CONCLUSION

This study was conducted to determine the microbiological and physicochemical quality of dry salted wild mullet (*V. seheli*) stored at ambient temperature (22 ± 1°C) and refrigerator (4 ± 1°C) for 180 days.

The results of the present study showed that the mullet muscle samples had satisfactory bacteriological quality with no coliform and *E. coli*. This study also revealed that the protein, lipid, ash, TVB-N and histamine, values of salted fish stored at ambient temperature and refrigerator were significantly ($P < 0.05$) increased gradually during the storage period. However, the bacterial load, water activity (A_w) value and the moisture content of salted fish stored at ambient temperature and refrigerator were significantly ($P < 0.05$) decreased gradually throughout the storage period.

Our results demonstrated that the tested salted wild mullet had greater than the legal limit of TVB-N and histamine, this could be due to the fact that the mullet muscle samples had been seriously contaminated during preparation and processing practices. Therefore, we suggest careful monitoring of TVB-N and histamine contents in these products. The findings of this study would, therefore, be helpful to researches in future studies and to the manufacturers to develop better processing and preservation strategy for salted fish to provide for the better protection of consumers. Our research will continue and seek to identify and analyze the bacterial communities that are associated with dry salted wild bluespot mullet (*V. seheli*).

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