Shelf-Life of Indian White Shrimp *Fenneropenaeus indicus* Stored in Different Icing Conditions

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Abstract: The Shelf-life of farmed Indian white shrimp *Fenneropenaeus indicus*, formerly *Penaeus indicus* stored in ice using three different ratios of ice for 22 days was evaluated. During the storage period, changes in sensory characteristics, TMA-N levels, pH values and total bacterial count (TBC) were investigated, where the results showed a clear deterioration in the appearance, texture and odor of *F. indicus* from the 10th day in the samples stored at a shrimp to ice ratio of 1:1 and from the 12th day in the samples stored at a ratio of 1:2, while no such deterioration was observed in the samples stored at ratio of 1:3 until the 18th day of storage. The TMA-N levels increased with time during the icing storage. The TBC of the normal flora in the flesh of *F. indicus* increased with the time of storage. Changes in the sensory characteristics were associated with the changes in TMA-N, pH and TBC, showing that the 1:2 ratio did not significantly extend the shrimp shelf-life compared to 1:1, whereas 1:3 significantly delayed the deterioration rate of quality, providing the longest shelf-life and the highest quality shrimp. The shelf-life extended to 9, 11 and 17 days at ratios of 1:1, 1:2 and 1:3 (shrimp to ice), respectively. Therefore, for storage purposes in ice, using a large amount of ice at a 1:3 ratio is recommended, as it extended the shelf-life to the greatest extent in this study.

Keywords: shelf-life, Indian white shrimp, *Fenneropenaeus indicus*, sensory analysis, bacterial count, TMA-N

Introduction

Fish are an important food source for humans, as they contain animal protein with a high nutritional value, and their prices are relatively low compared with other meats. Fish are also available accessible to the poor and rich alike. Amongst fishes and crustaceans, shrimps is important in human nutrition and health. They serve as a rich source of protein, calcium, vitamins and

omega-3 highly unsaturated fatty acids (n-3 HUFA), which have been connected to the prevention of cardiovascular diseases (Jamal 2000; Bragagnolo and Rodriguez-Amaya 2001; Heu *et al.* 2003; Sirot *et al.* 2008; Ouraji *et al.* 2009). On the other hand, they are also accountable for human intoxication and infection, with 10 to 20% of food-borne illnesses attributed to the consumption of fish (Pilet and Leroi, 2011). Fishes, as well as shrimps, constitute a main

part of the protein consumption in many places in the world, as they are high in protein (15-20%) with large amounts of all essential amino acids, and they provide approximately 3.0 billion people around the world with approximately 20 percent of their intake of animal protein (FAO, 2010; Pilet and Leroi, 2011). Penaeid shrimp have been known to inhabit the Red Sea since three centuries ago (De Man, 1882). They are an Indian white shrimp (*P. indicus*) species originating from the Indian Ocean (Lee and wickins, 1992). There were fewer than 20 fish farms in Saudi Arabia during the 1980s until the 1990s. The number of fish farms increased seriously in 2002 to be 103 farms after that it was increased 10 2008 to be 227. Generally the aquaculture in the present time locally concentrate on tow species as its high benefits, tilapia in freshwater and white shrimp in marine aquaculture, because of that farmers are now starting to diversify their aquaculture operations into marine fish culture (Fisheries and Aquaculture Sector statistics, 2004). The main guide for the consumer is the shelf life, that regarding to the starting of deterioration in the food and the used procedure (NZFSA, 2005). It is an important property of any food and is of interest to everyone in the food chain, from producers to consumers. Recently, consumers look h standard of handling

between purchase and consumption to minimize unliked changes in the quality of sensory sensory (Kilcast and Subramaniam, 2000). As the shortness of the shelf-life of the shrimp, the evaluation of shelf-life became an important factor to all market staff. High bacterial count does not always mean the spoilage of the food because only some of the total normal bacteria contributes to the spoilage (Anonymous, 1985). 25% of the supplied food has been lost due to spoilage which is a high percentage globally (Anonymous, 1985). So that, the microbial activity which could cause food spoilage is a field of an important concern. (Gram and Dalgaard, 2002; Gram and Huss, 1996). As the shrimp is a perishable food with high sensitivity to spoilage due to the neutral post mortem pH of its flesh (> 6), containing of trimethylamine and amino acids, and many other factors increase of deterioration (Man and Jones 2000; Mendes *et al.*, 2002). Sensory factors such as texture, taste, odor, also total bacterial count and trimethylamine-nitrogen or TMA-N usually uses to evaluate the degradation of shrimps (Armenta *et al.*, 2006). The production of TMA-N is dependent on the bacterial activity as well as from an endogenous enzyme (Green-Petersen, 2010). A higher general sensory quality of fish products available to consumers might induce a

higher consumption of fish. It might also be possible to induce a higher consumption of fish by obtaining more knowledge about how differences in sensory quality influence consumers' preferences for fish products and using this knowledge to guide the industry to design products with high consumer preferences (Green-Petersen, 2010). The present study detects and recommends freshness stages and spoilage stages by using microbial and chemical changes (that occur inside the shrimp's flesh during icing storage) and linking them with sensory changes. It also contributes a proper way to keep the shrimp in ice by recommending a better ratio of shrimp to ice to extend the shelf-life. There have been several studies of the shelf-life of shrimp (Tsironi *et al.*, 2009; Kirschnik *et al.*, 2006; Al-Dagal *et al.*, 2000; Fatima *et al.*, 1988). In one study of the shelf-life of chilled shrimp (*Penaeus*) collected from five sources in the Arabian Gulf and stored in ice using a 1:1 ratio, changes in microbial psychrotrophs and the chemical and sensory characteristics of shrimp were assessed every 72 hrs for nine days of icy storage (Al-Dagal *et al.*, 2000). There is a lack in the information and studies of storing in ice and the deterioration of shrimp, A comprehensive study is needed to identify freshness and quality indicators of shrimp

stored at zero and subzero ice storage (Qingzhu, 2003).

Materials and Methods

Raw materials and experimental design

Samples of Indian white shrimp *F. indicus* with an average body weight of 32.8 g and 14-18 cm length were collected from the National Aquaculture Group, Al-Lith, Jeddah, Kingdom of Saudi Arabia, preserved immediately with ice in insulated polystyrene containers, and transferred to the laboratories of the Faculty of Marine Sciences building in Obhur. The samples were washed with sterile seawater in a large pot, the average weight and length were determined, and they were stored with ice in layers in clean plastic insulated containers.

The samples were divided into three different treatments differing by the ratio of shrimp to ice (1:1, 1:2 and 1:3). All the shrimp was covered with crushed ice completely to insure the freshness of the samples inside the ice cooler containers. Re-icing was performed every 24 hours, and the temperature of the cooler contents was measured to confirm the difference in temperature among the three treatments of the experiment. The lowest temperature was approximately 1-1.5°C in treatment III (1:3 shrimp to ice), the highest was

approximately 2.5 - 3 °C in treatment I (1:1 shrimp to ice), and the intermediate temperature was approximately 1.7- 2.5 °C in treatment II (1:2 shrimp to ice). The containers were stored at room temperature. Throughout the period of study, many samples of shrimp were taken every 72 hours for testing, including chemical, sensory and microbial tests. The study was terminated when the arbitrators rejected samples and when the chemical parameters of spoilage appeared.

Sensory analysis

The sensory characteristics of shrimp were judged by a panel of experienced

persons (arbitrators) of Marine Science Faculty who have sufficient experience in this subject, enabling them to detect the primary indicators of spoilage on the basis of a 10 point scale. The sensory characteristics studied included the general appearance (inclusive of color), odor, and texture of shrimp. The scores were given on a decreasing order scale with 10–9 for excellent, 8–7 for good, 6–5 for fair and acceptable, 4–3 for poor and 2–1 for very poor. The score sheet in table (1) was used (Jeyasekaran *et al.*, 2006). The mean of the scores given by the panel represented the general sensory quality of the shrimps.

Table 1- Score sheet employed for sensory evaluation of *Penaeus indicus*

Score	Odor	General appearance	Texture
10	Seaweedy, characteristic of the species	Head completely attached to body; head, body and tail with characteristic color	Firm, elastic, hard shell/body
9	Slightly seaweedy, fresh-cut grass	Head still attached to body; head, body and tail with characteristic color	Fairly firm, slightly elastic
8	Slight characteristic odor of the species	Head, body and tail with slight fading of characteristic color	Slightly soft body/shell
7	Neutral to bland	Head, body and tail with slight fading of characteristic color	Slightly soft body/shell
6	Slightly ammoniacal	Slightly loose carapace, head with slight blackening; body and tail exhibiting light black spots and fading of characteristic color	Slightly soft body/shell
5	Urea, slightly fishy	Head almost completely black and slightly loose; tail exhibiting marked discoloration	Soft body and shell
4	Offensive, sulfide	Head loose and almost completely black; body and tail exhibiting black color	Soft body and shell
3	Ammoniacal, sulfide	Head slightly detached from body and almost completely black; body and tail black in color	Sponge-like body
2	Strong sulfide	Head slightly detached from body and completely black; body and tail exhibiting dark black color	Body sponge-like
1	Strong sulfide, urea, fecal, strong ammoniacal	Head slightly to completely detached from body and completely black; body and tail exhibiting dark black color	Mushy, very soft papery shell

Microbiological analysis

The direct viable count (DVC) method was used to measure the total bacterial count (TBC) of normal flora in the flesh of the marine shrimp *F. indicus*. The TBC was estimated by the surface inoculation of 0.1 ml of five dilutions using a digital pipette on Marine Agar (2216 oxoid) plates in triplicate and incubation at 20.7°C for 7 days. The colonies developed on the plates were counted and expressed as colony forming units, and the cfu/g was calculated.

pH measurement

Sample of shrimp flesh (10 g) was minced and transferred to a beaker (capacity of 250 ml) with 90 ml distilled water and was homogenized by shaking for 60s (Tsironi *et al.*, 2009). The pH of this homogenized sample was measured using a pH meter (Amel Instruments 338 pH meter).

Measurements of TMA-N

The trimethylamine-nitrogen (TMA-N) in shrimp was extracted and estimated by homogenizing 10 g of shrimp flesh with 20 ml of 7.5% (mass/volume) aqueous trichloroacetic acid (TCA) solution and subsequently centrifuging the homogenate at 3000 rpm for 15 min. The supernatant liquid was placed in a volumetric flask and enough 7.5% TCA was added to make up a

total volume of 25 ml. A 2 ml volume of the shrimp extract was placed into a 40 ml-amber vial containing a stirring bar together with 5 ml of a salted (30% mass/volume NaCl) aqueous solution and 1 ml of formaldehyde (39% mass/volume). Then, 2 ml of NaOH (10 M) were injected through the septum. A 3 μ l xylene drop containing 0.015% mass/volume of picric acid was then formed at the needle tip of a microsyringe and exposed to the headspace of the sample stirred at 1100 rpm for 3.5 min. The extract solution must be refrigerated in a water-ice bath before extraction to extend the extraction time and thereby enhance the extraction efficiency of TMA-N. Finally, the extract solution was placed on the pedestal of a spectrophotometer to obtain the corresponding analytical signal (Pena-Pereira *et al.*, 2010).

Data analysis

Statistical analysis was performed using the statistical package SPSS, version 18. Descriptive statistics (mean $\pm$ standard deviation or standard error) of the analysis results of the physical, chemical and microbiological data were calculated for each treatment. Significant differences between treatment means was determined by a parameters method using one-way ANOVA followed by Duncan's test ($P <$

0.05). Sensorial data were analyzed by a non-parametric method using the Kruskal-Wallis test (Kirschnik *et. al.* 2006, Kruskal and Wallis 1952).

Results

Sensory analysis

Table 2- Panel scale of sensory characteristics of *F. indicus* during storage in the three different icing conditions.

Days	Treatments*								
	Treatment (I)			Treatment (II)			Treatment (III)		
	Odor	General appearance	Texture	Odor	General appearance	Texture	Odor	General appearance	Texture
1st	9.9 ± 0.08 ^a	9.9 ± 0.06 ^a	9.9 ± 0.06 ^a	9.9 ± 0.58 ^a	9.9 ± 0.06 ^a	9.9 ± 0.06 ^a	9.9 ± 0.058 ^a	9.9 ± 0.06 ^a	9.9 ± 0.06 ^a
4th	9.1 ± 0.15 ^b	8.5 ± 0.15 ^b	9.6 ± 0.15 ^a	9.5 ± 0.25 ^{ab}	9.1 ± 0.15 ^{ab}	9.8 ± 0.06 ^{ab}	9.7 ± 0.058 ^a	9.5 ± 0.15 ^{ab}	9.8 ± 0.10 ^a
7th	8.1 ± 0.21 ^c	7.2 ± 0.20 ^c	8.5 ± 0.15 ^b	8.3 ± 0.21 ^{bc}	8.8 ± 0.15 ^{ab}	8.8 ± 0.15 ^b	9.1 ± 0.21 ^a	9.1 ± 0.15 ^{bc}	9.6 ± 0.15 ^{ab}
10th	6.4 ± 0.21 ^d	6.5 ± 0.60 ^c	6.3 ± 0.43 ^c	7.5 ± 0.50 ^c	8.1 ± 0.21 ^b	7.2 ± 0.20 ^c	8.2 ± 0.36 ^b	8.5 ± 0.15 ^{cd}	9.1 ± 0.21 ^b
13th	4.5 ± 0.23 ^e	2.7 ± 0.25 ^d	4.4 ± 0.58 ^d	7.1 ± 0.26 ^c	5.5 ± 0.53 ^c	6.7 ± 0.21 ^c	7.5 ± 0.25 ^{bc}	8.1 ± 0.21 ^d	7.5 ± 0.25 ^c
16th	2.4 ± 0.31 ^f	2.0 ± 0.32 ^d	2.1 ± 0.43 ^e	5.4 ± 0.49 ^e	3.0 ± 0.85 ^d	4.3 ± 0.26 ^d	7.1 ± 0.40 ^c	7.1 ± 0.26 ^e	6.4 ± 0.21 ^d
19th	1.3 ± 0.46 ^g	1.1 ± 0.21 ^e	1.3 ± 0.46 ^{ef}	4.5 ± 0.26 ^{ef}	2.0 ± 0.32 ^{de}	3.0 ± 0.85 ^e	6.1 ± 0.38 ^d	5.2 ± 0.53 ^f	4.6 ± 0.31 ^e
22 nd	1.1 ± 0.23 ^g	1.0 ± 0.15 ^e	1.0 ± 0.15 ^f	3.1 ± 0.86 ^f	1.0 ± 0.18 ^e	1.0 ± 0.15 ^f	5.2 ± 0.30 ^e	2.9 ± 0.26 ^g	4.0 ± 0.29 ^e

* Treatment (I) ; 1shrimp : 1 ice ratio. Treatment (II); 1shrimp: 2 ice ratio. Treatment (III); 1shrimp: 3 ice ratio. Values are means ± standard error (SE). Different small letters in each column indicate significant differences ($P < 0.05$).

Microbiological analysis

The TBC in the three different conditions were measured during the storage in ice, as is shown in table (3). Generally, the bacterial load in the flesh increased from an initial load of 3.41×10^3 cfu/g to 5.30×10^6

The changes in the sensory properties of *F. indicus* stored with ice in three different icing conditions for 22 days in this study are shown in table (2). The freshness was judged by the group of experts on the basis of sensory characteristics such as texture, general appearance and odor.

cfu/g in treatment (I), to 4.80×10^6 cfu/g in treatment (II), and to 9.06×10^5 cfu/g in treatment (III) after 22 days of storage in ice ($P < 0.05$). It is clear that the low bacterial load in treatment (III) indicates the positive effect of additional ice.

Table 3- Total bacterial count (TBC cfu/g) of normal flora in the flesh of *F. indicus* during storage in ice in the three different conditions.

Days	Treatment (I)	Treatment (II)	Treatment (III)
1 st	$3.41 \times 10^3 \pm 2.37 \times 10^1$ a*	$3.41 \times 10^3 \pm 2.37 \times 10^1$ a	$3.41 \times 10^3 \pm 2.37 \times 10^1$ a
4 th	$4.33 \times 10^3 \pm 5.77 \times 10^1$ a	ND	$3.66 \times 10^3 \pm 8.43 \times 10^2$ a
7 th	ND**	ND	$7.85 \times 10^3 \pm 5.08 \times 10^2$ b
10 th	$1.25 \times 10^5 \pm 8.08 \times 10^3$ ab	$3.70 \times 10^4 \pm 1.16 \times 10^3$ a	$1.02 \times 10^4 \pm 5.77 \times 10^1$ c
13 th	$2.74 \times 10^5 \pm 9.24 \times 10^3$ b	$1.10 \times 10^5 \pm 1.73 \times 10^3$ b	$5.35 \times 10^4 \pm 1.20 \times 10^3$ d
16 th	$5.25 \times 10^5 \pm 1.27 \times 10^4$ c	$4.46 \times 10^5 \pm 3.35 \times 10^4$ c	$8.90 \times 10^4 \pm 5.77 \times 10^2$ e
19 th	ND	$1.71 \times 10^6 \pm 1.73 \times 10^3$ d	$6.40 \times 10^5 \pm 5.77 \times 10^2$ f
22 nd	$5.30 \times 10^6 \pm 1.86 \times 10^5$ d	$4.80 \times 10^6 \pm 9.24 \times 10^3$ e	$9.06 \times 10^5 \pm 5.77 \times 10^2$ g

*Means $\pm$ standard error (SE). Mean values are obtained from three samples analyzed in triplicate. Different letters in each column indicate a significant difference ($P < 0.05$) based on the one-way analysis of variance of raw data followed by Duncan's post hoc test. **ND= No data found.

pH measurement

The changes in the pH values of the shrimp flesh in the three different icing conditions are shown in table (4). The results indicate

Table 4- Changes in pH values of flesh of shrimp *F. indicus* during storage in ice in the three different conditions.

Days	Treatment (I)	Treatment (II)	Treatment (III)
1 st	6.76	6.76	6.76
4 th	6.82	6.77	6.75
7 th	6.87	6.78	6.75
10 th	6.95	6.84	6.80
13 th	7.03	6.96	6.83
16 th	7.10	7.00	6.87
19 th	7.49	7.14	7.03
22 nd	7.68	7.49	7.44

that the pH values increased during storage in the three treatments from 6.76 to 7.68 in treatment (I), to 7.49 in treatment (II), and to 7.44 in treatment (III) at $P < 0.05$.

* Treatment (I) ; 1shrimp : 1 ice ratio. Treatment (II); 1shrimp: 2 ice ratio. Treatment (III); 1shrimp: 3 ice ratio. Values are means.

Measurements of TMA-N

Changes in the trimethylamine-nitrogen (TMA-N) levels in Indian white shrimp (*F. indicus*) stored in different ratios of ice are shown in figure (1). The TMA-N results of show increasing trends, the first significant increases at $P < 0.05$ observed on the 4th day for all three treatments, gradually continuing the first treatment (I) until the 22nd day (Fig. 1).

Figure 1- Changes in TMA-N values in *F. indicus* in the three treatments during storage in ice.

Means in the same treatment followed by different lowercase letters and means in the same day of each treatment followed by different capital letters, are significantly different ($P < 0.05$). Treatment I = shrimp to ice 1:1 ratio, Treatment II = shrimp to ice 1:2 ratio, Treatment III = shrimp to ice 1:3 ratio.

Discussion

Sensory analysis

In table (2) the sensory analysis of the stored Indian white shrimp (*F. indicus*) show that the lowest sensory scores were given to the shrimp stored in ice at 1:1 and 1:2 shrimp to ice ratios. The shrimp stored in ice at a 1:3 ratio was awarded the highest sensory scores, indicating a higher quality or a slower spoilage rate than in the other treatments throughout the storage period. Similar effects were observed in a previous study of quality changes of shrimp (Zeng *et al.*, 2005). The shelf-lives of the samples in the three treatments were as follows. The shrimps stored in ice at the 1:1 ratio were found to be organoleptically suitable for consumption when they were stored for 9 days with daily re-icing, similar to results reported in previous studies about the shelf-life of *P. indicus* stored in ice (Al-Dagal *et*

al., 2000, Joseph *et al.*, 1998). Shrimps stored in ice at the 1:2 ratio were acceptable up to 11 days, while shrimps stored in ice at the ratio of 1:3 were found to be acceptable up to 17 days. To maintain the quality of fresh shrimp, it must be stored with a 1:3 ratio of shrimp to ice, depending on the conditions and the storage period (Hendiy, 1983).

Microbiological analysis

The total bacterial count (TBC) of normal flora in Indian white shrimp (*F. indicus*) stored in ice in three different conditions (1:1, 1:2, 1:3 ratios) showed that the TBC in the flesh at the start of measurements (24 hours after the catch) was measured as 3.41×10^3 cfu/g. When comparing the TBC results in this study with the standard limit (10^5 cfu/g) from ICMSF, (1986), the results show that the TBC in the flesh did not exceed the limit until the 16th day of the experiment for the 1:1 and 1:2 ratios, and for the 1:3 ratio, it did not reach the standard limit until the end of the experiment. Generally, as shown in table (3), a lower bacterial load was observed in the 1:3 ratio, indicating that this treatment helps reduce the bacterial load in shrimp. It could also be explained by the reduction of the temperature in the 1:3 ratio compared with the 1:1 and 1:2 ratios. The increase of

melted water in the 1:1 and 1:2 ratios during the 24 hours before the re-icing and draining of the liquid water could also help the bacteria increase in number (Zeng *et al.*, 2005).

pH measurement

The pH values of shrimp meat provide valuable information about its quality change. In the three treatments, the pH value of the Indian white shrimp *F. indicus* stored in ice was recorded to be between 6.76 to 6.87 until the 7th day of storage in ice (Table 4). The measurement of the pH continued until the end of experiment, with the pH value increasing to 7.68 by the 22nd day of the experiment with a 1:1 ratio and to 7.49 with a 1:2 ratio. The ratio of 1:3 recorded a pH value of 7.44 on the 22nd day of storage, a lower value. In a previous study on the shelf-life of *P. indicus* stored in ice, the pH at the beginning of the experiment recorded a high value (7.18 – 7.25) and reached 7.70 on the 9th day of the study (Al-Dagal *et al.*, 2000), while in the present study, it did not exceed 7.00 until the 10th day for the 1:1 ratio, the 13th day for the 1:2 ratio, and the 16th day for the 1:3 ratio.

pH values between 7.50 – 7.75 are still accepted as safe values for food and are not

considered spoilage indicators (Nickelson, 1992).

Measurements of TMA-N

The TMA-N levels increased gradually in all three treatments during the iced storage ($P < 0.05$). The increase in TMA-N has been recorded by many previous studies of *P. indicus* stored in ice (Bindu *et al.*, 2012). The TMA-N level, which indicates the extent of protein breakdown, usually by bacteria or enzymes, gradually increased with storage time, as observed in earlier studies (Mahmud *et al.*, 2007; Ali *et al.*, 2010; Reddy *et al.*, 2012).

The acceptable limit of TMA-N for fishery products is in the range of 10-15 mg/100 g (Connell, 1995). The TMA-N levels in the present study exceeded the acceptable limit by the 10th, 13th, and 16th day in the 1:1, 1:2 and 1:3 ratios, respectively (Fig. 1). Considering the sensory results, which indicate that the shrimp samples were still acceptable on day 16 at 1:2 ratio and day 19 at the 1:3 ratio (Table 2), it could be argued that TMA-N may not be a suitable spoilage indicator, or otherwise the threshold values may be shifted upwards for white shrimp. The TMA-N levels in the shrimp stored with a 1:3 ratio were within the acceptable limit of 10 - 15 mg/100 g during the first 16 days of the experiment but increased by the

19th day of the storage period to above 15 mgN/100 g, although they were still organoleptically rated as acceptable. While they were within the acceptable limit (< 14 mgN/100 g) and they were organoleptically rated as acceptable at the 1:2 ratio until the 13th day of storage, they increased to 20.5 mgN/100 g by the 22nd day of the storage period. At a ratio of 1:1, the TMA-N levels of the shrimp were within the acceptable limit until the 10th day (< 14.3 mgN/100 g) but increased to 24.6 mg N/100 g by the 22nd day of storage. The TMA-N was significantly different for different storage periods (Fig. 1). In general, the TMA-N values stayed well below the acceptable limit (10 - 15 mg/100 g) during the first 7 days of the experiment. Statistically, there are significant effects observed in the increase in the TMA-N value when using different ratios of ice in this study at $P < 0.05$. Figure (1) shows that the 1:3 ratio was the best treatment to extend the shelf-life of shrimp stored in ice, and a reduction in the TMA-N values was noticed upon increasing the ratio of ice to shrimp in the three treatments during the storage period ($P < 0.05$).

Conclusions

The amount of ice used has a direct effect on the shelf-life and product quality of *F. indicus*, as a large amount of ice causes

comparatively less spoilage than a small amount. A 1:3 ratio of shrimp to ice creates unfavorable environmental conditions for bacteria, which slows down the bacterial growth and thereby increases the shelf-life, while a ratio of 1:1 allows increased bacterial growth, which reduces the shelf-life. Therefore, it is recommended to use a large amount of ice to extend the shelf-life, as observed in the shrimp to ice ratio of 1:3 in this study. TMA-N was shown to be a good indicator of shrimp spoilage in this study, and its levels increased during the ice storage. The high levels of TMA-N indicated critical and advanced stages of shrimp spoilage. The total bacterial count (TBC) of the normal flora in *F. indicus* also showed increases with the time of storage, and higher levels were recorded in the 1:1 and 1:2 ratios.

Generally, the shelf-life of *F. indicus* in treatment (III) was found to be 17 days, compared with 9 and 11 days in (I) and (II), respectively.

From the present study, the recommendations are as follows:

- 1) As shrimp is an important source of animal protein, there is a need for further studies to mitigate the losses of the world's food supply caused by incorrect storage methods, which exceeds 25% globally.

2) It is recommended to use a shrimp to ice ratio of 1:3, to extend the shelf-life for shrimp.

3) A comprehensive study of the normal bacterial flora in water and caught shrimp, which also have an effect on the storage of shrimp, could help to further extend the shelf-life.

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العمر التخزيني للروبيان الابيض الهندي *Fenneropenaeus indicus*

المخزون في ظروف مختلفة في الثلج

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المملكة العربية السعودية

تم تقييم العمر التخزيني الافتراضي لروبيان الاستزراع الهندي الابيض *Fenneropenaeus indicus* في ثلاث نسب مختلفة من الثلج ولمدة ٢٢ يوما، وتم تقييم عدة عوامل لجودة الروبيان وهي الخصائص الحسية ومستويات التراي ميثيل امين وكذلك درجة الحموضة والعدد الكلي البكتيري خلال فترة التخزين. وأظهرت النتائج تدهور واضح في الخصائص الحسية من حيث المظهر والملمس والرائحة للروبيان ابتداء من اليوم العاشر من التخزين في الثلج لنسبة (١:١) روبيان: ثلج، وكان التدهور واضحا في جودة الروبيان المخزن بنسبة (٢:١) روبيان: ثلج، في حين لم يلاحظ التدهور الحسي لجودة الروبيان في التخزين بنسبة (٣:١) روبيان : ثلج حتى اليوم الثامن عشر من التخزين . كما ارتفعت مستويات التراي ميثيل امين والعدد الكلي للبكتيريا مع استمرار التخزين في الثلج. وكان واضحا ارتباط تدهور الخصائص الحسية اثناء فترة التخزين مع التغيرات في مستويات التراي ميثيل امين ودرجة الحموضة والعدد الكلي البكتيري. ودلت النتائج ان نسبة (٢:١) روبيان: ثلج من التخزين لم تكن ذات جدوى لحفظ جودة الروبيان، كما كان الحال بنسبة التخزين (١:١) روبيان : ثلج , مع ظهور فرق كبير ذو جدوى في تخزين الروبيان في ما نسبته (٣:١) روبيان : ثلج , حيث كانت فعالة اكثر في حفظ الروبيان وعدم تدهور جودته. العمر التخزيني امتد الى ٩ , ١١ , ١٧ يوما على التوالي للروبيان المخزون في نسب ثلج مختلفة (١:١) ، (٢:١) ، (٣:١) روبيان : ثلج ، لذلك يوصى باستخدام كمية كبيرة من الثلج في عملية تخزين الروبيان , حيث تزيد هذه النسبة من الثلج العمر التخزيني وتحافظ على جودة الروبيان المخزون.