Studies on the post-mortem changes in shrimp and prawn during ice storage: I. Organoleptic and physical changes

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Abstract
The organoleptic characteristics such as appearance, textural condition, colour and odour indicated that the M. rosenbergii stored in ice for 5-6 days were acceptable for processing in the industry while P. monodon under similar ice storage condition were acceptable for 8-9 days. In both species, samples stored in headless condition in ice had longer shelf life than that of stored in head-on condition.

Physical changes were evaluated by determining expressible moisture and breaking strength of sample of muscles. The expressible moisture increased continuously in both samples with the lapse of storage period. The expressible moisture increased up to around 44% in 4-5 days of ice stored M. rosenbergii muscle while it was around 40% in 8-9 days ice stored P. monodon. At the end of 9 days of ice storage, the expressible moisture content in M. rosenbergii increased up to 60%, while it was up to 47% in P. monodon after 11 days of ice storage. The breaking strength declined from 0.78 kg/cm² to 0.53 kg/cm² in tiger shrimp after 8 days of ice storage, while in case of immediately killed prawn, the breaking strength of muscle was 0.8 kg/cm² which declined to 0.43 to 0.35 kg/cm².

Key words: Penaeus monodon, Macrobrachium rosenbergii, Ice storage, Quality change

Introduction
In Bangladesh, considerable quantity of post-harvest loss of prawn and shrimp are reported to occur at different stages of handling and transportation. The major source of raw material supply is various categories of shrimp farms located in the coastal belt of Khulna, Bagerhat, Satkhira and Cox's Bazar area. The collection of raw material passes through a number of steps and finally delivered to the market and exporting industries using road, rail and water transport (Uddin and Das 1994). It takes usually 12-44 hours to transport the shrimp in iced condition from shrimp farm to the processing plants. Depending on the supply of raw material, in the industry, the shrimps after beheading are stored in the processing plants for about another 2-3 days particularly when the raw material supply is abundant compared to per day capacity utilization of the plants.

A considerable information is available on the organoleptic and physical changes in shrimp during ice storage but mostly on the species from colder region. However, very
little is known on the giant freshwater prawn and marine tiger shrimp of the tropical region. An essential prerequisite for designing the infrastructure for handling, transportation and marketing is to know how long each particular commercial species can be kept in ice condition. This paper reports the results of the organoleptic and physical changes of freshwater and marine water shrimp during ice storage.

**Materials and methods**

**Materials**

Giant freshwater prawn (*Macrobrachium rosenbergii*) and marine tiger shrimp (*Panaeus monodon*) were used for the study. Live fresh water giant prawns were collected from the local market of Bangladesh Agricultural University Campus, Mymensingh. They were caught by the cast net from the nearby Brahmaputra river by fishermen and transported to the market in live condition. While the tiger shrimp were obtained in lots from farms of Khulna region in live condition and transported to the Laboratory. It took about 18–24 hours from catch point to destination before start the subsequent experiment.

**Experimental condition**

The samples (*M. rosenbergii* average size 25/kg, *Penaeus monodon* average size 22/kg) were obtained in lots several times from March to October'98. The samples of each species were divided into two groups, head-on and headless conditions and stored separately in ice in an insulated box. At selected time interval, a desire number of samples were used to assess the degree of freshness by evaluating organoleptic and physical changes.

**Organoleptic assessment**

The organoleptic methods used in this study is based on the existing procedure of the Fish Inspection and Quality Control Service (FIQC) of the Department of Fisheries (DOF), the Government of Bangladesh which is a modified version of Multilingual Guide to freshness grade described by Howgate *et al.* (1992). Six members panel were constituted to evaluate the organoleptic quality changes of giant fresh water prawn and tiger shrimp on the basis of odor, texture, color (with shell), color of flesh and general appearance of shrimp. The quality was evaluated by grading the shrimp using the score from 5 to 25 in case of fresh shrimp and 4 to 20 in case of boiled shrimp. The grade defined in terms of the total number of points were: 22 to 25 considered as very good or excellent, 19-21 good, 14-18 acceptable, 8-13 bad and 5 to 7 very bad condition in case of raw shrimp. In case of boiled shrimp, the score point 18-20 considered as very good/excellent, 14-17 good, 11-13 acceptable, 7-10 bad and 4 to 6 very bad.
Expressible moisture test

The expressible moisture test was determined according to Saban et al. (1987). At selected time interval, the samples were taken from the container and cut into a number of pieces. About 1 g of muscle was placed between double layer of filter paper No. 102 and passed at 1 kg/cm² for 3 minute. Decrement of weight was measured and the ratio of decrement to the original weight was defined as expressible moisture (%) in the following formula:

\[
\%\text{ of expressible moisture} = \frac{W_2 - W_1}{W_1} \times 100
\]

Where, \(W_1\) = Weight of the shrimp muscle before compression.

\(W_2\) = Weight of the shrimp muscle after compression.

Textural test

Textural test was determined according to Nakayama et al. (1993) with some modification. The shell of shrimp was removed and cut into equal pieces of 2 cm from near the middle portion of the shrimp body. The puncture test was done by measuring breaking force of the shrimp muscle against the penetration of a ball type plunger. The cutting muscle was placed on the pan of an electronic balance and pressed by a spherical plunger (6 mm diameter) over it until penetrate into it. The force (in gram) required to break the shrimp muscle by the plunger was recorded from the balance display window.

Results

The organoleptic quality changes in tiger shrimp and fresh water prawn during ice storage are shown in the Tables 1 and 2, respectively for fresh shrimp and Table 3 for cooked boiled tiger shrimp. The organoleptic characteristics such as appearance, textural condition, colour and odour judged by panel members indicated that the shrimp in a lot were acceptable condition in term of commercial standard for processing in the industry up to 5th days of ice storage. On the other hand, when the shrimp obtained from the same lot and stored in ice in headless condition were organoleptically acceptable condition up to 6th days in ice. That is keeping time of headless shrimp in ice can be increased one day more than that of head-on shrimp.

Table 1. Changes in organoleptic qualities of different days of ice stored head-on giant freshwater prawn

<table>
<thead>
<tr>
<th>Stored period or days</th>
<th>Organoleptic qualities</th>
<th>Number</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 day</td>
<td>Fresh bright shining and iridescent. Firm consistent and elastic texture. With characteristics of white colour of flesh. Odour and colour of shell is natural</td>
<td>25</td>
<td>Very good</td>
</tr>
<tr>
<td>1st day</td>
<td>Slight loss of brightness. Moderately soft and some loss of elastic texture. Slight change in colour of flesh and shell. Odour is neutral.</td>
<td>20</td>
<td>Good</td>
</tr>
<tr>
<td>2nd day</td>
<td>Slight loss of brightness. Some softening texture. Slight pink colour of flesh and shell. Neutral odour.</td>
<td>19</td>
<td>Good</td>
</tr>
<tr>
<td>3rd day</td>
<td>Slight dullness and loss of brightness. Some softening texture. Slight</td>
<td>18</td>
<td>Acceptable</td>
</tr>
</tbody>
</table>
pink colour of flesh and shell. Slight sour odour.

4th day

5th day
Definite dullness and loss of brightness. Soft and watery texture. Pink colour of flesh and shell is discolour. Ammonical odour.

6th day

7th day

8th day
General appearance is dull. Soft and juicy texture.

Table 2. Changes in organoleptic qualities of different days of ice stored head-on tiger prawn

<table>
<thead>
<tr>
<th>Stored period or days</th>
<th>Organoleptic qualities</th>
<th>Number</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st day</td>
<td>Fresh bright shining and irridescent. Firm consistent and elastic texture. Colour of flesh is white. Odour and colour of shell is natural.</td>
<td>25</td>
<td>Very good</td>
</tr>
<tr>
<td>2nd day</td>
<td>Slight loss of brightness. Moderately soft and some loss of elastic texture. Slight pink colour of flesh and shell-odour is neutral.</td>
<td>20</td>
<td>Good</td>
</tr>
<tr>
<td>3rd day</td>
<td>Slight loss of brightness. Some softening texture. Slight pink colour of flesh and shell-odour is neutral.</td>
<td>19</td>
<td>Good</td>
</tr>
<tr>
<td>4th day</td>
<td>Slight dullness and loss of brightness. Some softening texture. Flesh and shell is slight pink colour and odour is slight sour.</td>
<td>18</td>
<td>Acceptable</td>
</tr>
<tr>
<td>5th day</td>
<td>Definite dullness and loss of brightness. Some softening texture. Flesh and shell slight pink colour. Odour is slight sour.</td>
<td>16</td>
<td>Acceptable</td>
</tr>
<tr>
<td>6th day</td>
<td>Definite dullness and loss of brightness. Some softening texture. Slight pink colour of flesh. Shell is brownish red and odour is slight sour.</td>
<td>15</td>
<td>Acceptable</td>
</tr>
<tr>
<td>7th day</td>
<td>Definite dullness and loss of brightness. Some softening texture. Pink colour of flesh and shell is brownish red. Odour is slight sour.</td>
<td>14</td>
<td>Acceptable</td>
</tr>
<tr>
<td>8th day</td>
<td>Definite dullness and loss of brightness. Some softening texture. Pink colour of flesh and shell is discolour. Odour is rotten.</td>
<td>14</td>
<td>Acceptable</td>
</tr>
<tr>
<td>9th day</td>
<td>General appearance is dull. Texture is soft and watery. Flesh is pink colour and shell is brownish red. Odour is ammonical.</td>
<td>11</td>
<td>Bad</td>
</tr>
<tr>
<td>10th day</td>
<td>General appearance is dull. Texture is soft and watery. Flesh pink colour and shell is discolour. Odour is rotten.</td>
<td>8</td>
<td>Bad</td>
</tr>
<tr>
<td>11th day</td>
<td>General appearance is dull. Texture is soft and juicy. Flesh is dull/discolour. Shell is also discolour. Odour is rotten</td>
<td>5</td>
<td>Very bad</td>
</tr>
</tbody>
</table>

Table 3. Changes in organoleptic qualities of different days of ice stored boiled head-on tiger shrimp

<table>
<thead>
<tr>
<th>Stored period or days</th>
<th>Organoleptic qualities</th>
<th>Number</th>
<th>Overall quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st day</td>
<td>Difficult to remove the shell. Natural smell while chewing. Odour is natural and texture is very good.</td>
<td>20</td>
<td>Very good</td>
</tr>
<tr>
<td>2nd day</td>
<td>Difficult to remove the shell. Neutral smell while chewing. Odour is neutral and texture is good.</td>
<td>17</td>
<td>Good</td>
</tr>
<tr>
<td>3rd day</td>
<td>Slight difficult to remove the shell. Neutral smell while chewing. Odour is neutral and texture is good.</td>
<td>19</td>
<td>Good</td>
</tr>
</tbody>
</table>

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4th day  Slight difficult to remove the shell. Slight sweet odour while chewing. Odour is neutral and texture is good.
5th day  Slight difficult to remove the shell. Slight sweet odour while chewing. Odour is neutral and texture is slightly hard.
6th day  Slight difficult to remove the shell. Slight sweet odour while chewing. Odour is slightly sour and texture is slightly hard.
7th day  Slight difficult to remove the shell. Sour odour while chewing. Odour is slightly sour and texture is slightly hard.
8th day  Easy to remove the shell. Sour odour while chewing. Slight sour odour. Texture is slightly hard.
9th day  Easy to remove the shell. Sour odour while chewing. Odour is ammonical and texture is very hard.
10th day Easy to remove the shell. Rotted odour while chewing. Sour odour. Soft and watery texture

14  Good
13  Acceptable
12  Acceptable
11  Acceptable
  9  Bad
  7  Bad
  5  Very bad

Similar studies were also conducted with tiger shrimp either head-on or headless condition. The head-on samples were acceptable condition up to 8 days and the headless shrimp for 9 days. The changes in organoleptic characteristics of ice stored tiger shrimp were also judged upon boiling based on fishy, flavours and odours. The results obtained upon cooked were more or less similar to that of the results obtained judging organoleptic qualities in iced condition.

Fig. 1 shows the changes in expressible moisture (EM) of head-on giant tiger shrimp during ice storage. The EM of shrimp muscle gradually increased during ice storage. Organoleptically the shrimp were found acceptable condition up to 8 days of ice storage and the expressible moisture content at that time was recorded around 41%. However, at the end of 11 days of ice storage the expressible moisture content increased to around 47% and organoleptically the samples were rejected with objectionable odour.

Fig. 2. Changes in expressible moisture (EM) content of freshwater giant prawn (head-on and headless) during ice storage.

Similar studies were also conducted with giant fresh water prawn either in head-on or headless conditions. The expressible moisture of live prawn immediately after killed was around 17% (Fig. 2.). A rapid increase in expressible moisture content was found
after one day both in head-on or head less condition. Organoleptically the freshwater prawns were acceptable condition up to 4-5 days and the expressible moisture content increased up to around 44%. At the end of 9 days of storage expressible moisture was 69% for head less sample and head on about 57%. At this stage, both the samples were already rotten and not fit for consumption. The result of the present study indicated that expressible moisture content up to around 44% was upper limit for organoleptically acceptable condition both in head on and head less prawn.

Studies were also conducted on the changes in breaking strength in shrimp muscle slice. The textural test of head-on giant tiger shrimp was done with one day old ice stored shrimp. The shrimp showed obvious sign of fresh organoleptic characteristics and the breaking strength of muscle at this stage was 0.78 kg/cm². Then the breaking strength declined gradually with the increase of storage period. After 8 days of storage when the sample reached the upper limit for organoleptically acceptable condition, the breaking force decreased down to 0.53 kg/cm² together with considerable loss of expressible moisture. At the end of the 11 days of ice storage when the shrimps were rejected by organoleptic assessment, the breaking strength decreased to 0.42 kg/cm². In fresh water prawn the breaking strength of immediately killed shrimp muscle was 0.8 kg/cm². Organoleptically fresh water prawn stored in ice either head-on or head less condition were acceptable for 4 to 5 days and the breaking force during the period dropped to 0.43 to 0.35 kg/cm².

Discussion

The shelf life of _P. monodon_ and _M. rosenbergii_ determined by various organoleptic and physical aspects varied greatly between two species. The available reports suggest that the shelf life of shrimp/prawn during ice and frozen storage varies from species to species, chemical composition and ambient temperature in which they are kept (Takada et al. 1988, Santoso et al. 1992, Yamagata and Low 1995). The results of the present study demonstrated that the quality of shrimp for shrimp for export by seafood industry could be maintained in ice 5 to 6 days for freshwater shrimp and 8 to 9 days on brackishwater shrimp either head-on or head less conditions after catch. Spots on the shell, offensive sulphide smell and loose shell were the reasons commonly attributed for spoilage as reported for _P. monodon_ by Fonseka and Ranjini (1994).

Saban, et al. (1987) found that the expressible moisture increased gradually with the lapse of storage time irrespective of temperature. The largest change was observed for the specimens stored at −20°C. It increased from 22% to around 30% after 3 months and then decreased to 18-22% after 9 months irrespective of storage temperature adopted.

The breaking force in head on muscle was comparatively higher than that of head less samples throughout the storage period. Organoleptically giant fresh water prawn stored in ice either head-on or head less condition was acceptable for 4 to 5 days and the breaking force during the period dropped to 0.43 to 0.35 kg/cm². A negative correlation between the textural changes and expressible moisture content either in fresh water prawn or marine shrimp was established where expressible moisture increased with the
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decrement of breaking force. The breaking force for giant fresh water prawn immediately after death was 0.8 kg/cm$^2$ which decreased to around 0.6 kg/cm$^2$. On the other hand, initial expressible moisture content of the fresh water shrimp was 16% which increased to around 30% during the same period. At the end of the storage period the breaking force decreased from 0.8 kg/cm$^2$ to 0.28-0.31 kg/cm$^2$ while expressible moisture increased from about 16% to 69% either in head-on or head less condition. Nakayama et al. (1993) reported that the breaking strength of stressed and unstressed fish muscle decreased sharply within 16 and 31 hrs after death respectively.

Conclusions

The organoleptic characteristics indicated that the freshwater prawn were found acceptable condition in term of commercial standard for processing up to 5 days in head-on and 6 days in headless condition during ice storage. On the other hand, marine tiger shrimp were found acceptable condition up to 8 days in head on and 9 days in headless during similar storage.

References


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