POST-HARVEST QUALITY LOSS OF SHRIMP (*Penaeus monodon*) IN THE VALUE CHAIN OF SOUTHWESTERN REGION (SATKHIRA) IN BANGLADESH

Muhammad Yousuf Ali¹,²*, Zakaria Mahmud², Md. Abdur Rashed³, Momotaz Khanom² and Md. Golam Sarower²

¹Molecular Genetics Lab, EEBS, Science and Engineering Faculty, Queensland University of Technology (QUT), QLD 4001, Australia
²Fisheries and Marine Resource Technology Discipline, Khulna University, Khulna – 9208, Bangladesh
³Deputy Director, Quality Control, Department of Fisheries, Bangladesh Ministry of Fisheries and Livestock

*Corresponding author: yousufku@gmail.com

ABSTRACT

The present study was conducted to assess the post-harvest quality loss of shrimp (*Penaeus monodon*) in the value chain of Satkhira region in Bangladesh. The investigation was carried out in August 2011 to November 2011 in nine selected shrimp farms, three faria, three depot and two factory receiving point of different locations including Kaligong, Munsigong and Asasoni in Satkhira region of Bangladesh. Quality assessment included proximate analysis of protein, total volatile base nitrogen (TVB-N) and trimethylamine (TMA). TVB-N and TMA contents were determined by using Conway’s micro-diffusion technique and protein by Kjeldhal method. Protein contents of thirty-six samples ranged from 17.43±.99% to 23.38±0.21% in wet weight method. At the farm level, the protein content was 23.38±0.21%, 22.90±0.26% and 21.98±0.71%, respectively in Kaligong, Munsigong and Asasoni station. At Faria level, protein contents was 21.50±0.64%, 21.07±0.54% & 20.85±0.60% respectively in Kaligong, Munsigong and Asasoni station. At depot, protein content was 20.42±0.56%, 19.86±0.88% and 18.96±0.88% in Kaligong, Munsigong and Asasoni respectively. In factory receiving point, protein content was 19.38±0.46%, 18.80±0.46% and 17.43±0.99% respectively in Kaligong, Munsigong and Asasoni. Protein loss of Shrimp was found as 4%, 4.10% and 4.55% in Kaligong, Munsigong and Asasoni respectively from farm to factory receiving point. From farm to factory receiving point, average protein loss was recorded as 4.22%. The TVB-N contents varied between 15.30±0.04 mg/100g to 25.46±0.99 mg/100g. The amount of TMA ranged between 12.75±0.02 mg/100g and 19.26±0.22 mg/100g. Factors like longer duration of harvesting, delayed icing, exposure at high temperature, excess water usage in shrimp, packed under pressure, piling up shrimp on a dirty floor, rough handling resulted considerable loss of shrimp quality.

Keywords: Shrimp (*Penaeus monodon*), Protein, Quality loss, value chain, TVB-N, TMA and Satkhira

1. INTRODUCTION

Shrimp (*Penaeus monodon*) is one of the main exporting items in Bangladesh. The frozen shrimp industry is the second largest export sector of Bangladesh which earned some US$ 412.173 million or 2885.212 crore taka in 2009-10. About 51,599.15 MT shrimp was exported in 2009-10. (DoF, 2011). Especially the southern part of Bangladesh plays a vital role in production of...
shrimp. Greater Khulna region (Satkhira, Khulna and Bagerhat) provides maximum amount of shrimp production. Though Satkhira, Khulna and Bagerhat are the main region for shrimp culture yet Satkhira district plays the main role in this regard. The main cultivated species in this region is *Penaeus monodon*, more commonly referred to as Bagda. Bagda (*Penaeus monodon*) has been recognized in the last few years as one of the most important aquatic resources of Bangladesh. This species has a number of advantages in comparison to other crustaceans. It exhibits fast growth which reaches marketable size within 4 to 5 months; has high nutritional value. It has high demand in domestic and international market as well.

Satkhira district has a great contribution to the export of shrimp. Exportable shrimp requires special care to retain as much as practicable its original physical appearance, odor and organoleptic conditions. It must be free from dirt, filth, pathogenic organisms, unwanted chemicals and any antibiotics even in the minutest quantity. The importing countries, particularly the EU, USA and Japan are highly conscious about quality, food hygiene and safety. Now-a-days there are always issues and complaints from the buyers that shrimp undergoes a huge quality loss (protein) during handling and processing in the marketing channel. To justify this complain, an intensive and comprehensive research is important in this regard. Though some works (for example; Ali et al., 2008c; Ali et al., 2010) have already been carried out in this respect, but there is not sufficient information on protein loss at different stages of marketing channel of shrimp in Satkhira region. It is essential to know the degree of quality losses from farm to processing plants. It is also important to find out the reasons why such losses occur at farm and depot level during handling and transportation. Some causes of quality loss have been reviewed by Ali et al., (2008c) but they did not present any lab-based practical report on the protein loss in the value chain. Considering all these issues, the investigation was undertaken aiming at assessing the protein loss; observing the variation in TVB-N (Total Volatile Base Nitrogen) and TMA (Tri-methylamine) contents in the value chain of shrimp in Satkhira region of Bangladesh.

2. MATERIALS AND METHODS

2.1. Study area

The study was conducted at Sannasirchak, kajla and Tarali in Kaligong, at Harinagar, Borigoaliny and Gathkhal in Munsigong and at Protapnagar, Bardal and Goaldanga in Asasoni in Satkhira district. It is the southern part of greater Khulna region and very near to Sundarbens Mangrove Forest. The region being very close to the Bay of Bengal, saline water is available here to support shrimp farming in a large scale.

2.2. Sample collection

Shrimps (*Penaeus monodon*) were collected from four distribution points i.e. Gher (enclosed shrimp farm), Faria, Dipo/Agent and Processing Plant in August to November, 2011. The size of the shrimps ranged from 16 to 25 grade.

Nine farms were selected in Kaligong, Munsigong and Asasoni Station. Those farm were situated at Sannasirchak, Kajla and Tarali in Kaligong upazila, at Harinagar, Borigoalini and gathkhal in Munsigong station, at Protapnagar, Bardal and Goaldanga in Asasoni upazila. 27 shrimps collected from each farm. Shrimps were collected from Faria after 1-2 hours of farm’s shrimp collection. Samples were collected from three Dipots namely Dhrubo Fish in Satkhira, Al- Amin Fish in Noyabiki/ Chonabrige in Shamnagar, Shovo soni Fish in Satkhira. After one day of farm’s harvest, shrimps were collected from Dipo/Agent. Samples were collected at factory receiving point namely- Rupali Sea Food Ltd. in Rupsa & Atlas Sea Food Ltd. in Rupsa of Khulna district. It was carried out at evening.

Total six Kg shrimp of 16-25 grades were purchased from the harvesting point (Gher). All the shrimp were not of same grades. Equal amount of shrimps was taken for normal practice and controlled study. Three shrimp from each basket were separately kept into two ice box for biochemical analysis. Following this method shrimps were taken to each point of distribution point (depots, agents and processing plants) where the usual practices were done and the sample were collected in separate box. From each point of distribution channel shrimps were brought to the Fish Nutrition and Quality Control Lab of Fisheries & Marine Resource Control Lab of Fisheries & Marine Resource
Technology (FMRT), Discipline Khulna University, Khulna.

2.3. Biochemical Quality Assessment

2.3.1. Protein Determination

The protein % of the samples were determined on the basis of total nitrogen content with Kjeldahl digestion method (AOAC, 1984; Pearson, 1976, Bradstreet, 1965).

2.3.1.1. Digestion

0.2-0.5 gm of sample was weighed and inserted into a Kjeldahl flask and 2 gm of resolvent and 5 ml of concentrated H\textsubscript{2}SO\textsubscript{4} were added into the flask. The content of the flask was digested by heating in a micro Kjeldahl nitrogen digesting apparatus for 45 minutes till the clear color appears. After completion of digestion, the flask was transferred from digesting apparatus and let it be cooled for 10 minutes until the temperature decreased up to about room temperature.

2.3.1.2. Distillation

15 ml of 2% boric acid (H\textsubscript{2}BO\textsubscript{3}) was taken in a conical flask and 2-3 drops of Tashiro’s indicator were added into the flask. The delivery tube of the apparatus was arranged with its tip below the surface of 1 S ml boric acid. Then adding 70 ml of distilled water diluted the digested materials and 0.5 gm of sandy zinc was added in the Kjeldahl flask. About 25 ml of 33-40% caustic soda (NaOH) solution was poured slowly in the flasks along sidewall. The flask was then connected to the Khjeldahl nitrogen distillation apparatus and distilled it for about 30 minutes to obtain 25-30 ml distilled solution. Distilled solution was stored in the conical flask through delivery tube.

2.3.1.3. Titration

The distilled solution stored in the conical flask was taken and titrated against 0.1 (N) HCl solution.

2.3.1.4. Calculation

The percentage of gross portentous nitrogen was calculated with the formula: \%

\[ \text{N} = \frac{\text{Volume of HCl} \times \text{Normality of HCl} \times 0.014}{\text{weight of sample (gm)}} \times 6.25 \]  

(\text{conversion factor})

2.3.2. Moisture Determination

The moisture content was determined by the method described by Pearson (1976). About 5 gm of shrimp sample was taken in porcelain. The sample was weighed accurately by using an electric balance and dried in an oven at 105°C for 24 hrs. Drying, cooling, (in a desiccator) and weighing were continued for a constant final weight. The percentage of moisture content was calculated as:

\[ \text{Moisture (\%)} = \frac{\text{(weight of sample - weight of dried sample)}}{\text{weight of sample}} \times 100 \]

2.3.3. TVB-N and TMA-N Determination

TVB-N and TMA-N were determined according to procedure stated in the manual of Siang and Kim (1992).

2.3.3.1. Extract Preparation

The extract of shrimp was prepared by mixing 2gm of the ground muscle with 8ml of 4\% Trichloroacetic Acid in a 50 ml Mackerty bottle and was homogenized well. It was left for 30 mins at ambient temperature with occasional grinding. Then, it was filtered through filter paper (whatman no. 1) The filtered solution was kept in Mackerty bottle and was labelled. The filtered solution was also stored in a refrigerator at 0-4°C (to prevent any further chemical, bacterial, enzymic break down of the muscle).

2.3.3.2. TVB-N:

Three Conway's units were taken which had been thoroughly cleaned with a neutral detergent to remove any containment. To the edge of the outer ring of each unit was applied the gum. Using a micropipette 1 ml of inner ring solution was pipetted into the inner ring of each unit. Into the outer ring of each unit, was pipetted 1 ml of the sample extract. 1 ml of Saturated K\textsubscript{2}CO\textsubscript{3} solution
was carefully pipetted into the outer ring of each unit, carefully to prevent the entering the inner ring and immediately the units were covered and closed with clip. The solution of the units was then mixed gently, to prevent any solution mixing from one ring to other. After then the units were placed in an incubator at 45°C for 45 mins. After this the units covers were removed and the inner ring solution, now a green color was titrated with 0.02N HCl using a burette (50ml) until green color solution turned to pink. An average titrated volume of HCl was found from the result of three titration for each muscle sample. For each volume the TVB-N volumes were calculated. A blank test was also carried out using 1 ml of 1% TCA, instead of sample extract.

2.3.3.3. TMA-N:

Trimethyl Amine in shrimp muscle was determined by the Conway Micro-diffusion technique. Prior to addition of K$_2$CO$_3$, 1 ml of 10% neutralized formalin was added to the extract to react with ammonia and thus allowed only the TMA to diffuse over the unit.

3. RESULTS AND DISCUSSION

3.1. Protein content

The protein contents of shrimp (Penaeus monodon) at different stages of value chain in Satkhira region are presented in Table 1 and the overall trends of changing protein contents are shown in Fig. 1. The protein content was decreased gradually from farm to factory receiving point in Satkhira region. Protein loss in shrimp was observed as 4.0%, 4.10% and 4.55% respectively in Kaligong, Munsigong and Asasoni marketing channel from farm to factory receiving point (Table 1). Average protein loss was 4.22 % from farm to factory receiving point in this region (Table 1). Hossain (2011) reports 4.51% protein loss from farm to factory receiving point in Khulna distribution channel. The protein loss in our study are probably due to delayed icing, putting at open place with high temperature, improper handling and transportation as well as biochemical reaction (especially decomposition) in shrimp body.

Protein contents of 36 samples were found in the range of 17.43±.99% to 23.38±0.21% in wet weight method (Fig. 1). In Kaligong distribution channel, protein contents were found as 23.38±0.21%, 21.50±0.64%, 20.42±0.56% and 19.38±0.46% at farm, faria, dipo (depot) and factory receiving point respectively (Table 1). In Munsigong channel, protein contents were found as 22.90±0.26%, 21.07±0.54%, 19.86±0.88% and 18.80±0.46% at farm, faria, depot and factory receiving point respectively. In Asasoni marketing channel, protein contents were found 21.98±0.71%, 20.85±0.60%, 18.96±0.88% and 17.43±0.99% at farm, faria, dipo and factory receiving point respectively (Table). Rahman et al., (2004) report 19.79±4.36 % protein content in shrimp (P. monodon) body. Another study found 18.4% to 19% protein in Shrimp (Fenneropenaeus penicillatus) on the basis of wet weight (Kher-un-Nisa and Razia Sultana, 2010).

Table 1: Protein contents (%) in shrimp (P. monodon) at different points of value chain in Satkhira region

<table>
<thead>
<tr>
<th></th>
<th>Farm</th>
<th>Faria</th>
<th>Depot</th>
<th>Factory Gate</th>
<th>Protein Loss (%) from Farm to Processing Gate</th>
<th>Average Protein Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaligong</td>
<td>23.38±0.21</td>
<td>21.50±0.64</td>
<td>20.42±0.56</td>
<td>19.38±0.46</td>
<td>4.00</td>
<td>4.22 %</td>
</tr>
<tr>
<td>Munsigong</td>
<td>22.90±0.26</td>
<td>21.07±0.54</td>
<td>19.86±0.88</td>
<td>18.80±0.46</td>
<td>4.10</td>
<td></td>
</tr>
<tr>
<td>Asasoni</td>
<td>21.98±0.71</td>
<td>20.85±0.60</td>
<td>18.96±0.88</td>
<td>17.43±0.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.2. Biochemical assessment

3.2.1. Total Volatile Base Nitrogen (TVB-N)

The results of TVB-N contents of shrimp (*Penaeus monodon*) at different stages of value chain in Satkhira region are given in Table 2 and overall pattern changes in TVB contents is illustrated in Fig. 2. TVB-N contents increased gradually from farm to factory receiving point in Satkhira region. On an average basis TVB contents increased by approximately 6.37 mgN/100g during the period from farm to factory receiving point. Hossain (2011) observed this increase as 26.55 mgN/100g in shrimps of Khulna marketing channel. In our study, at farm level, when shrimp were fresh, TVB-N contents in shrimp were recorded as 15.30±0.04 mg/100g, 18.47±1.49 mg/100g and 19.91±1.18 mg/100g in Kaligong, Munsigong & Asasoni channels respectively (Table 2). At faria level, it was observed as 17.98± 3.77 mg/100g, 21.70±02.87 mg/100g & 22.81±0.61mg/100g in Kaligong, Munsigong & Asasoni stations respectively. At depot, The TVB-N values were found as 19.35±0.56 mg/100g, 23.24±0.88 mg/100g & 24.04±2.23 mg/100g in Kaligong, Munsigong & Asasoni stations respectively. At Factory receiving point, the TVB-N value was recorded as 22.85±0.46 mg/100g, 24.48±0.46 mg/100g & 25.46±0.99 mg/100g in Kaligong, Munsigong & Asasoni stations respectively (Table 2).

In our study, the value of TVB-N slowly increased as time elapsed. This result is an agreement with some previous studies as well (Jayasinghe et al., 2006; Ali et al., 2008a; Pushparajanand and Soundarapandian, 2009, Ali et al., 2010). The level of total volatile nitrogenous bases increases after spoilage begins and thus can be used as an index of spoilage. Using TVB-N as such an index of spoilage does not distinguish the origin or component of these volatile compounds, hence its use is more general. The use of TVB-N as an index of spoilage was first proposed by Shewan (1957). The low value of TVB-N initially is an indication of quality of fresh shrimp or fish while the high value may be due to action of autolytic enzymes and spoilage bacteria which might have passed their lag phase (Adebona, 1982).

Table 2: TVB-N contents (mgN/100g) in shrimp at different points of value chain in Satkhira region.

<table>
<thead>
<tr>
<th></th>
<th>Farm</th>
<th>Faria</th>
<th>Depot</th>
<th>Factory Gate</th>
<th>Increase from Farm</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaligong</td>
<td>23.38</td>
<td>22.9</td>
<td>21.98</td>
<td>21.50</td>
<td>0.62</td>
<td>22.13</td>
</tr>
<tr>
<td>Munsigong</td>
<td>21.50</td>
<td>20.76</td>
<td>20.85</td>
<td>20.42</td>
<td>0.54</td>
<td>20.68</td>
</tr>
<tr>
<td>Asasoni</td>
<td>19.35</td>
<td>19.86</td>
<td>18.86</td>
<td>18.8</td>
<td>0.51</td>
<td>19.01</td>
</tr>
</tbody>
</table>

Figure 1: Changing trends of protein % at different points of value chain in Satkhira region.
Kaligong & Munsigong & Asasoni & to Processing Gate & Increase
15.30±0.04 & 17.98±3.77 & 19.35±0.56 & 22.85±0.46 & 7.55 & 6.37
18.47±1.49 & 21.70±2.87 & 23.24±0.88 & 24.48±0.46 & 6.01
19.91±1.18 & 22.81±0.61 & 24.04±2.23 & 25.46±0.99 & 5.55

3.2.2. Tri-methylamine (TMA)

TMA contents of shrimp at different points of distribution channel are presented in Table 3 and the overall variation patterns of TMA are illustrated in Fig. 3. TMA ranged between 12.75±0.02 mg/100g to 19.26±0.22 mg/100g. TMA contents increased gradually from farm to factory receiving point in Satkhira marketing channel. TMA contents increased by 5.22 mgN/100g during the period from farm to the receiving room of processing plant (Table 3). Hosain (2011) observed this increase as 24.39 in Khulna region, which is quite more than our present study. This difference probably owing to unequal handling and preservation facilities and distance from farm to processing plant.

In Kaligong marketing channel, TMA contents were found as 12.75±0.02 mg/100g, 16.39±2.31 mg/100g, 16.28±0.56 mg/100g and 18.10±1.75 mg/100g respectively in farm, faria, dipo and factory receiving point (Figure 3). In Munsigong channel, TMA contents were found as 12.88±0.02 mg/100g, 16.39±2.31 mg/100g, 17.24±0.55mg/100g, 17.97±0.90 mg/100g respectively in farm, faria, dipo and factory receiving point. In Asasoni channel, TMA contents were recorded as 13.67±1.18 mg/100g, 16.53±0.88 mg/100g, 18.53±2.56 mg/100g and 19.26±0.22 mg/100g respectively in farm, faria, dipo and factory receiving point (Table 3).

In the present study it was found that the value of TMA increased over time. TMA was found at small amount which indicates freshness of the shrimps. In the value chain, as time went forwards, value of TMA was increased rapidly by activities of bacteria and enzyme. At the farm when shrimp were fresh,
TMA contents in shrimp were recorded very low in all stations. At factory receiving point, the values of TMA were found slightly higher in all stations. This result is in agreement with previous studies of Ali et al., (2008a) and Ali et al., (2010).

TMA is, because of its universal production in all shrimp and fish species, an excellent indicator for the onset of spoilage and for the different stages of spoilage. The fishy odor is produced when TMA reacts with fat in the muscle of shrimp/fish (Davies and Gill, 1936). In the course of spoilage, many off-odors are produced by bacteria, indicating the onset and development of spoilage. More TMA is produced from TMAO by bacterial action than by fish tissue enzymes. TMA produced by both these two actions is responsible for the ‘fish odor’ during spoilage (Jones, 1954).

Connell (1975) recommended 10 – 25 mg/100g TMA as acceptable for human consumption.

Table 3: TMA contents (mgN/100g) in shrimp at different points of value chain in Satkhira region.

<table>
<thead>
<tr>
<th></th>
<th>Farm</th>
<th>Faria</th>
<th>Depot</th>
<th>Factory Gate</th>
<th>Increase from Farm to Processing Gate</th>
<th>Average Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaligong</td>
<td>12.75±0.2</td>
<td>16.39±2.31</td>
<td>16.28±0.56</td>
<td>18.10±1.75</td>
<td>5.35</td>
<td>5.22</td>
</tr>
<tr>
<td>Munsigong</td>
<td>12.88±0.2</td>
<td>16.39±2.31</td>
<td>17.24±0.55</td>
<td>17.97±0.90</td>
<td>5.09</td>
<td></td>
</tr>
<tr>
<td>Asasoni</td>
<td>13.67±1.18</td>
<td>16.53±0.88</td>
<td>18.53±2.56</td>
<td>19.26±0.22</td>
<td>5.59</td>
<td></td>
</tr>
</tbody>
</table>

Fig 3: Variation trends of TMA contents at different points of value chain in Satkhira channel.
4. CONCLUSION

In the value chain of shrimp in Satkhira region, protein loss may be attributable to handling problem, high temperature, over stress on shrimp body, using bad quality water for washing, using bad quality ice for storage, long transportation etc. Bangladesh incurs a significant amount of loss in earning foreign currency when quality loss of the frozen products is detected by the importing countries. That is why measures should be taken to stop the quality loss of shrimp. Harvesting of shrimp should be done with minimum stress, infrastructure should be developed; for example the internal environment of depot and shrimp landing point in the factory gate should be well furnished. The time elapsed from farmer to factory should be kept minimum. The farmer and depot owner should be well trained about the quality loss of shrimp. During transportation, good quality ice should be used to maintain the required temperature and to minimize the decomposition rate. Good transportation system with preservation capacity should be facilitated to the shrimp handlers to reduce the time from farmer to factory gate.

References


