Quality Assessment of Smoked Shrimps (Traditional and Improved)Stored at Room Temperature (28 To 32°C) in Different Packs

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Abstract
To preserve shrimps, smoking or smoke curing is an ancient methods in practice since long before. The present study was conducted to prepare improved smoked shrimp from 4 different species of raw shrimps, namely Chali (*Metapenaeus brevicornis*), Chaka (*Penaeus indicus*), Horina (*Metapenaeus monoceros*) and Khogda (*Parapenaeopsis stylifera*) at laboratory condition, to observe the changes in sensory, biochemical and microbiological parameters of the both laboratory and traditionally prepared (at Koyra, Khulna) smoked shrimps of these species. The initial moisture level of improved smoked shrimps (Chali, Chaka, Horina and Khogda) ranged from 14.22±0.02%~16.15±0.03% with the highest value in Khogda, but the moisture content of traditional smoked Chali was 17.53±0.11%. After storage of 120 days the moisture reached to the ranged from 15.12±0.13% to 18.83±0.21%, protein content from initial 61.18± 91%~64.05±0.41% to 52.8 ±51%~57.61±0.84%, lipid content from initial 9.73±0.06%~10.05± 0.06% to 8.55±0.04%~9.10±0.06% and ash contents from initial 11.06±0.14%~16.36±0.08% to 14.28±0.08%~19.11±0.07%. For TVB-N values and microbial load also a same increasing trend was observed for the samples. From the obtained results of the study it could be concluded as- implementation of improved techniques for smoking able to extend the storage period of smoked shrimps and among different packs vacuum sealed pack is the most effective one for storage.

Key words: Fish stick, Mince, Quality change, Room temperature, Silver carp

Introduction

Bangladesh earns a considerable amount of foreign currencies by exporting fish, shrimps and other fisheries products (Islam and Haque, 2018). Shrimp as a single fishery has been contributed significantly to the national export earnings and to the economic development of Bangladesh. Secondary studies extensively indicate that the shrimp industry of Bangladesh is one of the most important contributors for economic nourishment at present and is the second largest export commodity of the country (Hossain and Islam, 1999). There are 24 fresh water and 36 marine shrimp species in our country, among the marine species only 4 species viz. *Penaeus monodon* (Tiger shrimp), *Penaeus indicus* (White shrimp) *Penaeus japonicus* (Kuruma shrimp) and *Penaeus duorarum* (Pink shrimp) are commercially cultured, industrially processed and exported from our country (DoF, 2008).

The peak of shrimp catch in Bangladesh is seasonal and during peak season the catch is much higher than the consumer's need. The shrimp catching area and landing centers of Bangladesh are located in the South-Eastern parts of Bangladesh. The bulk catches of South-East part of Bangladesh need to distribute to other regions and for keeping the quality unimpaired during transportation, application of some processing techniques are required. There is very little or no information about the processing method of shrimp. For preservation of small shrimps in rainy season, smoking is a good technique and is being used from the time immemorial due to no other alternative methods available for rainy season (Hoq *et al.*, 2006).

Smoking process depends on many factors which include surface area, water content and fat content of shrimp, temperature, relative humidity and air velocity. It is important to achieve required quality by optimizing temperature, humidity and moisture content through optimizing the smoking process for each species of shrimp. The quality of mechanical smoking kiln is related to the final water activity (a_w) and amount of smoke deposition on smoked product. Most bacteria do not grow and multiply at a_w values below 0.95 (Tapia *et al.*, 2008). Simultaneously with reducing moisture content, smoking process deposits smoke on body surface of shrimp. Smoke is the combination of chemical substances, which have anti-microbial effects and thus inhibit microbial growth. So, the cause of the longer storage life of smoked shrimp is not due to drying effect of smoke only but the preservative effects of the chemical compounds deposited on product from it.

The preparation of smoked shrimp includes washing of shrimps by clean water, draining of the water, spreading the shrimp on the wire mesh, smoking, and turning up the shrimps then after completion of smoking, cooling and packaging. In order to produce improve quality smoked shrimps, it is essential to have proper knowledge about all the factors related to harvesting, handing, transportation and production process of smoked shrimp. Quality assurance program and implementation of proper quality management system in every step of processing is of prime importance. For increasing the shelf life of smoked shrimp, packaging is an essential requirement. It is a means of conserving and preserving the product.

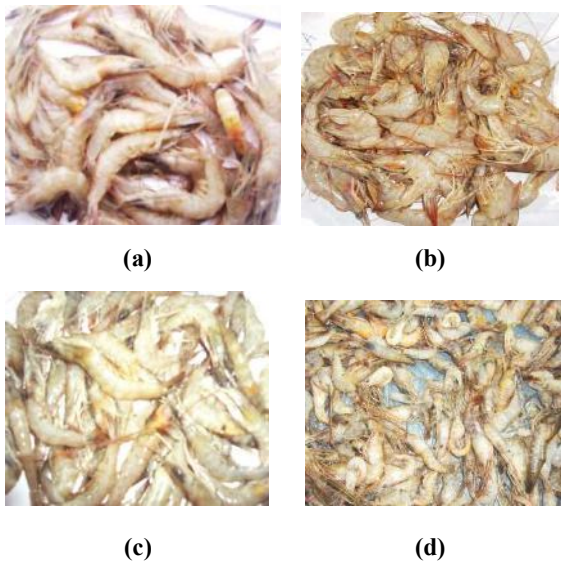
Shelf life study of the smoked shrimp is an important consideration in respect of business aspects and consumer health issues. Sensory, chemical and microbial assessment is necessary in order to determine the shelf life of the product. Considering the above facts, the present study was undertaken to prepare improved smoked shrimp in the laboratory and to assess the changes in quality parameters during storage at room temperature (28 to 32°C) in various packs.

Materials and Methods

The present experiment was carried out in the laboratories of Department of Fisheries Technology, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh.

Shrimp species

Four species of raw shrimps, namely Chali (*Metapenaeus brevicornis*), Chaka (*Penaeus indicus*), Horina (*Metapenaeus monoceros*) and Khogda (*Parapenaeopsis stylifera*)and smoked shrimps of same species were purchased from Koyra, Khulna and directly brought to the Fish Processing laboratory of Department of Fisheries Technology, BAU (Plate1).



(a) **(b)**

(c) **(d)**

Plate1. (a) Chali (*Metapenaeus brevicornis*), (b) Chaka (*Penaeus indicus*), (c) Horina (*Metapenaeus monoceros*) and (d) Khogda (*Parapenaeopsis stylifera*)

Production of improved smoked shrimp at laboratory condition

Smoking kiln

The smoking kiln was made locally using steel sheet as a rectangular box of 5.2 × 2.7 × 2.3 ft3 size (Plate2. h). The box or chamber was divided into two equal parts, horizontally by using a steel sheet and the bottom portion was used for burning saw dust as smoke source. The horizontal separator had a central circular hole of 8 inch diameter. The upper chamber had facilities of hanging 4-6mm iron rods supported from two sides as rack. Both the chamber had door which could be opened when needed. On the top, there was an outlet for smoke control. By controlling the lid of the outlet the smoke temperature inside the shrimp chamber i.e. the upper chamber could be controlled. To provide a sensitive thermometer, another small hole on the top was used to measure the temperature inside the chamber.

Preparation procedure of smoked shrimp (in laboratory)

Good quality fresh raw shrimps of 4 different specices were directly transported in an insulated box with ice (1:1) from Koyra, Khulnato BAU.Specific shrimp species were selected to prepare improved smoked shrimp by properly separating fish larvae, small fish, other shrimps, sea snails and other mollusks. For smoking of shrimps, wood and saw dust were burnt to produce smoke in smoking kiln. The smoke temperature varied between 60 to 70°C, which led to partially dry the shrimps within 4-5 hours. The saw dust used for smoking procedure were of black berry, mahogany, sirish, bel etc. tree and partially dried before using in the kiln. The saw dust was collected from a local saw-mill. The steps of smoked shrimp preparation is presented in Plate2.

Plate 2. Steps of improved smoked shrimp preparation in laboratory (a) collection of shrimp; (b) washing of shrimp in running tap water; (c) dewatering; (d) spreading of shrimp on racks of smoking kiln; (e) producing smoke; (f) smoking of shrimp; (g) closed view of smoking kiln during operation; (h) turning of srimps; (i) cooling of smoked srimp; (j) shrimp in non-sealed pack; (k) shrimp in air-tight pack; (l) shrimp in vacuum sealed pack.

Storage of smoked shrimp

Certain amount of each improved smoked shrimp samples were kept in non-sealed, air tight and vacuum sealed packs (Plate2.J,k,l). The traditionally prepared smoked shrimp samples (purchased from Koyra, Khulna) were also packed as done with improved samples. Then all the packed samples were stored at roomtemperature (28 to 30°C) for further analysis.

Organoleptic quality assessment

Sensory methods for organoleptic quality assessment are considered to be the most useful and dependable criteria for assessing the degree of freshness since human being are capable to detect defects from visual signs of deterioration such as loss of freshness and changes during storage. Organoleptic characteristic (general appearance, taste, flavor, texture, and color) of the smoked shrimp was examined by sensory methods (through sight, touch, taste, smelling etc.). The evaluation methods used in this study were based on one that is currently in use in various institution of the world (Larmond, 1977).The organoleptic and physical characteristics like color, texture and odor when broken etc. were evaluated by five members panel in the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh. The grading of smoked shrimps using score on the characteristics has been followed by AOAC (1990) freshness grade for fishery products with modification by the author for smoked shrimp as described in Table1 and Table2.

Table 1. Grading of smoked shrimps

Grade	Points	Comments
A	<2	Excellent/ Acceptable
B	2 to <5	Good/ Acceptable
C	5	Bad/ Rejected

Table 2. Determination of defect points of smoked shrimp

Characteristics	Defect	Defect point	Grade
1. Color of smoked shrimp	a) Bright red color	1	Excellent
	b) Dark red color	2	Acceptable
	c) Brownish	3	Acceptable
	d) Whitish	5	Rejected
2. Odor	e) Strong smoky sweet odor	1	Excellent
	f) Mild smoky odor	2	Acceptable
	g) Neutral odor	3	Acceptable
	h) Rancid off odor	5	Rejected
3. Texture	i) Crisp, fragile texture	1	Excellent
	j) Fragile texture	2	Acceptable
	k) Less fragile and elastic texture	4	Acceptable
	l) Powdery structure with whitish fungal growth	5	Rejected

Biochemical analysis

Proximate composition analysis

Proximate composition analysis of moisture, crude protein, lipid and ash were carried out of smoked shrimp samples were done according to the methods as described in AOAC (1990) with certain modifications.

Total Volatile Base- Nitrogen (TVB-N) value determination

Total Volatile Base Nitrogen (TVB-N) was determined according to the methods given in AOAC (1984) with certain modification.

Microbial analysis

Aerobic plate count was done by spread plate count method. Peptone diluent (0.2%) and plate count agar of commercial preparations or prepared in the laboratory as per method given in Cowan and Steel's Manual for the Identification of Medical Bacteria (Barraw and Feltheam, 1993) were used in the shelf life study of fish stick. Aerobic plate count was done by consecutive decimal dilution technique. According to International Standard Organization (ISO, 1965) APC was calculated by the following formula:

APC/g = C × D × 10/S CFU/g

Where,

C = Number of colonies found

D = Dilution factor

S = Weight of sample in grams

CFU = Colony forming unit

Statistical analysis

To analyze the data one-way analysis of variance and the general linear model using Windows for SPSS 9.0 were used. The Duncan's New Multiple Range Test (DMRT) was used to find the significant differences between storage periods.

Results and Discussion

Organoleptic quality assessment of smoked shrimps

The organoleptic qualities of traditional and improved smoked shrimps were evaluated on the basis of the color, odor, texture and overall other quality aspects and the results are presented in Table-3. The smoked shrimp of bright red color, strong smoky odor and crisp, fragile texture is considered excellent and preferred most by the consumers. In the present study, the color of traditional smoked chali ranged from dark red to reddish color and the odor was mild smoky. The texture of traditional smoked chali was fragile to elastic which showed the medium quality of the product. The average defect point of the traditional smoked Chali was 2.33(Acceptable). On the basis of the organoleptic observation traditional smoked chali found acceptable.

Table 3. Organoleptic quality of traditionally smoked chali and improved smoked shrimps of four different species

Sample name	Characteristics	Defect Characteristics	Defect points	Average Defect Points	Grade/Comments
Traditionally Smoked Chali	Color	Reddish color	3	**2.33**	**B** Acceptable
	Odor	Mild smoky odor	2		
	Texture	Fragile texture	2		
Improved smoked Chali	Color	Bright red color	1	**1.0**	**A** Excellent
	Odor	Strong Smoky odor	1		
	Texture	Crisp fragile texture	1		
Improved smoked Chaka	Color	Dark red color	2	**1.67**	**A** Acceptable
	Odor	Strong Smoky odor	1		
	Texture	Fragile texture	2		
Improved smoked Horina	Color	Bright red color	1	**1.0**	**A** Excellent
	Odor	Strong smoky odor	1		
	Texture	Crisp fragile texture	1		
Improved smoked Khogda	Color	Dark red color	2	**1.33**	**A** Excellent
	Odor	Strong smoky odor	1		
	Texture	Crisp fragile texture	1		

Among the improved smoked shrimps, Horina and Chali showed the preferable bright red color, and Khogda and Chaka showed dark red color. The organoleptic characteristics of improved smoked Chali showed better than those of traditionally smoked Chali. All of the improved smoked shrimps were of bright red color. The texture of the improved smoked shrimps was crisp and fragile which was achieved through proper moisture reduction. The average defect points of improved smoked Chali, Chaka, Horina and Khogda were 1.0, 1.67, 1.0 and 1.33, respectively. Improved smoked Chaka showed higher defect point than Horina, Chali and Khogda, mightbe due to the differences in the quality (size, freshness etc.) of the raw materials.

Changes in organoleptic characteristics of traditional and improved smoked chali during storage

Sensory characteristic (general appearance, taste, flavor, texture, and color) of the smoked shrimps were examined by sensory methods (through sight, touch, taste, smelling, etc.). This study was based on the method currently used by Fish Inspection and Quality Control (FIQC) of DoF with slight modifications which are summarized in Table-4.In case of non-sealed pack, the sensory quality of traditional smoked shrimp was good up to 60 days, whereas the quality of improved smoked shrimp were good till 90 days.In airtight pack, the smoked shrimps were more stable than non-sealed pack and the improved smoked chali was acceptable in this pack until 120 days and the traditional smoked chali up to 90 days. On the other hand sensory quality of smoked shrimps stored in vacuum sealed pack found very good even after storage of 120 days in this pack. Smoked shrimps stored in vacuum sealed pack scored quite near to those of smoked shrimps on "0" days of storage. During the observation the changes of color of different shrimp samples from whitish to brownish might occurred due to the oxidation of lipid during the storage period. Smoked shrimps stored in non-sealed pack were found more susceptible to lipid oxidation than other packs might be due to the action of air over these shrimps.

The results obtained in the present study is quite similar to the findings of Haq *et al*. (2008) who investigated the changes in quality of smoked shrimp during storage at room temperature for 105 days. He found that the sensory quality attributes decreased gradually throughout the storage period. In another study Haq *et al*. (2008) used polythene bag, gunny bag, hogla made basket for storing both traditional and improved smoked shrimp at room temperature (28 to 30°C) for longer period. Initially the traditional and improved smoked shrimps were bright red, sweet odor and fragile crispy texture. With the progress of storage time, the smoked shrimp absorbed atmospheric air, become rancid by hydrolysis. The product stored in polythene bag was comparatively in better condition than other two bags as polythene bag is less permeable of air than other two. These results are very similar to the finding of the present study.

Daramola *et al*. (2007) carried out a study on the changes in physicochemical and sensory characteristics of smoke-dried fish species stored at ambient temperature. Samples of fish were assessed weekly for physical attributes such as color, fragmentation, odor, taste and texture. Their results of the physical assessment showed a general decline in the physical attributes such as color, fragmentation, odor, taste and texture of fish during storage. Fluffy woolly mat of molds was noticed on *Clariasgar iepinus* from the 5th week of storage. There was a significant color change in most species as from the 6th week. The gradual decline in physicochemical and sensory characteristics of smoked fish products with the lapse of storage is in agreement with the present study.

Table 4. Changes in organoleptic Characteristics of traditionally smoked chali and improved smoked chali during storage at room temperature in different packs

Days	Characteristics					
	Non-sealed pack		Air tight pack		Vacuum pack	
	Traditional smoked Chacli	**Improved smoked Chaci**	**Traditional smoked Chacli**	**Improved smoked Chaci**	**Traditional smoked Chacli**	**Improved smoked Chaci**
0	Bright red color Strong smoky sweet odor Crisp and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture	Bright red color Strong smoky sweet odor Crisp and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture	Bright red color Strong smoky sweet odor Crisp and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture
15	Mild red color Mild smoky odor Fragile texture	Dark red color Mild smoky odor Stringy and fragile texture	Dark red color Strong smoky sweet odor Crisp and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture
30	Brownish color Neutral odor Fragile texture with powder	Mild red color Mild smoky odor Crispa, fragile texture	Reddish color Mild smoky odor Fragile texture	Dark red color Strong smoky sweet odor Stringy and fragile texture	Dark red color Strong smoky sweet odor Crisp and fragile texture	Bright red color Strong smoky sweet odor Stringy and fragile texture
60	* Whitish color Rancid, off odor Powdery structure with whitish fungal colony	Brownish color Neutral odor Less fragile and someelastic texture	Brownish color Neutral odor Fragile texture	Reddish color Mild smoky odor Fragile texture	Mild red color Mild smoky odor Elastic structure of muscle	Dark red color Strong smoky sweet odor Stringy and fragile texture
90		* Whitish color Rancid, off odor Powdery structure with whitish fungal growth	* Whitish color Rancid, off odor Powdery structure with whitish fungal colony	Brownish color Neutral odor Less fragile and some elastic texture	Brownish color Neutral odor Crisp texture with powder	Reddish color Mild smoky odor Crispa, fragile texture
120	----------	----------	----------	* Whitish color Rancid, off odor Powdery structure with whitish fungal growth	* Whitish color Rancid, off odor Powdery structure with whitish fungal colony	Brownish color Neutral odor Less fragile and some elastic texture

Changes in biochemical and microbiological parameters

Product preparation process and storing condition have effects on the quality parameters of a food product. Changes in the biochemical and microbiological parameters of smoked shrimps during storage at room temperature (28 to 32°C) in different packs are presented in Table-5.

Changes in biochemical parameters

Moisture

At the initial stage the moisture content of traditional smoked chali was found 17.53±0.11%. In improved smoked chali, chaka, horina and khogda the moisture contents were 14.22±0.13%, 16.02±0.02%, 15.36±0.05% and 16.15±0.12%, respectively. During storage in different packs the moisture content (%) of all the species of smoked shrimps increased with the lapse of storage period. After storage period of 15 days, the moisture contents (%) of traditional smoked chali found 19.94±0.13, 18.95±0.13 and 17.55±0.12 in non-sealed, air tight and vacuum sealed packs, respectively which increased to 32.88±0.21, 22.75±0.12and 18.83±0.21 after storage period of 120 days at room temperature. In case of improved smoked chali, chaka, horina and khogda a similar increasing

trend in moisture content (%) was followed (Table-5). The moisture contents (%) were found 18.53±0.13, 16.45±0.14 and 14.29±0.12 of non-sealed, air tight and vacuum sealed improved smoked chali on 30th day of storage, with the progress of storage period moisture content of these samples increased to 26.56±0.14, 18.09±0.11 and 14.78±0.15 on 90th day of storage indicating the slower rate of moisture increase of the smoked shrimp samples both in air tight and vacuum sealed packs.

Protein

The protein content of traditional smoked chali was found 61.18±0.91% and in improved smoked chali, chaka, horina and khogda the protein contents were 64.05±0.41 %, 62.15±0.54 %, 63.70±0.55% and 63.11±0.41 %, respectively. Protein content (%) of all the species of smoked shrimps stored in different packs decreased with the progress of storage period. After 15 days of storage at room temperature, the protein contents (%) of traditional smoked chali found 58.42±0.34, 59.39±0.66 and 60.21±0.45 in non-sealed, air tight and vacuum sealed packs, respectively which decreased to 44.78±0.22, 53.14±0.24 and 54.91±0.39 after storage period of 90 days. For all other samples-improved smoked chali, chaka, horina and khogdathe similar decreasing trend in protein content (%) was observed (Table5). The protein contents were obtained 63.70±0.55%, 62.15±0.57% and 62.89±0.51% of non-sealed, air tight and vacuum sealed improved smoked horina on 15th day of storage, with the lapse of storage time protein content of these samples decreased to 45.44±0.33 %, 53.11±0.55 % and 56.05±0.51 % on 120th day of storage indicating the faster rate of protein decrease of the smoked shrimp samples in non-sealed packs.

Lipid

On "0"of storage the lipid contents were found 9.24±0.05 %, 9.85±0.04 %, 9.96±0.06 %, 10.05±0.06 % and 9.36±0.06 % inof traditional smoked chali, improved smoked chali, chaka, horina and khogda, respectively. During storage the lipid content (%) of all the species of smoked shrimps decreased with the progress in storage period. The lipid contents (%)of traditional smoked chali found 8.75±0.04, 9.11±0.02 and 9.18±0.03 in non-sealed, air tight and vacuum sealed packs, respectively on 15th day of storage which decreased to 6.27±0.10, 6.79±0.08and 6.79±0.08on the storage date of 120 at room temperature. A similar decreasing trend in lipid content (%) was found in all other samples, such as- improved smoked chali, chaka, horina and khogda (Table 5). The lipid contents (%) were found 9.73±0.05, 9.88±0.06 and 9.94±0.01 of non-sealed, air tight and vacuum sealed improved smoked chaka on 15th day of storage, with the progress of storage period lipid content of these samples decreased to 7.96±0.05, 9.01±0.07 and 9.33±0.05 on 90th day of storage indicating the slower rate of lipid oxidation of the smoked shrimp samples both in air tight and vacuum sealed packs.

Ash

The ash contents were found 12.52±0.09%, 11.06±0.06 %, 11.79±0.07 %, 11.38±0.08% and 12.14±0.04 % in traditional smoked chali, improved smoked chali, chaka, horina and khogda, respectively. Ash content (%) gradually increased with the progress of storage peiod in all species of smoked shrimps. The ash contents (%) of traditional smoked chali found 14.52±0.05, 13.81±0.09 and 13.52±0.12 in non-sealed, air tight and vacuum sealed packs, respectively on 30thdays of storage at room temperature, which increased to 19.11±0.07, 16.46±0.06and 15.89±0.11 after storage period of 120 days. A similar increasing trend in ash content (%) was observed for all other samples- improved smoked chali, chaka, horina and khogda (Table5). The ash contents were obtained 12.88±0.05%, 12.49±0.07% and 12.42±0.05% of non-sealed, air tight and vacuum sealed improved smoked khogda on 15th day of storage, with the lapse of storage time protein content of these samples decreased to 15.96±0.07%, 14.52±0.09% and 14.00±0.08% on 90thday of storage indicating the faster rate of ash content increase of the smoked shrimp samples in non-sealed packs.

TVB-N Value

On "0" of storage the TVB-N values were found 15.83±0.08, 12.23±0.11, 14.05±0.13 and 13.14±0.10 (mg/100g) in of traditional smoked chali, improved smoked chali, chaka, horina and khogda, respectively. The TVB-N values of all the species of smoked shrimps increased with the progress of storage period. The TVB-N values of traditional smoked chali were found 18.69±0.09, 17.73±0.11 and 17.12±0.10(mg/100g) in non-sealed, air tight and vacuum sealed packs, respectively on 15th day of storage which decreased to 35.33±0.12, 30.15±0.10 and 25.72±0.11(mg/100g) on the storage date of 90 at room temperature. A similar increasing trend in TVB-N values was found for all other samples, such as-improved smoked chali, chaka, horina and khogda (Table 5). Among them, the TVB-N values were found 18.78±0.12, 17.34±0.12 and 15.42±0.15 (mg/100g) of non-sealed, air tight and vacuum sealed improved smoked horina on 30th day of storage, with the progress of storage period TVB-N values of these samples increased to 32.84±0.11, 29.89±0.12 and 25.94±0.14 (mg/100g) on 120th day of storage indicating that the rate of increase in TVB-N values in air tight and vacuum sealed packs is slower than in non-sealed pack.

Changes in microbiological parameter

Aerobic plate count (APC) of bacteria

At the initial stage of storage aerobic plate content (APC) of bacteria were found 3.6 0 x 10^3, 4.30 x 10^2,2.05x 10^3, 9.8 0 x 10^2 and 1.12 x 10^3 CFU/gin traditional smoked chali, improved smoked chali, chaka, horina and khogda, respectively at room temperature. During storage in different packs aerobic plate count (APC) of all the species of smoked shrimps increased with the progress of storage period. After

storage period of 15 days, the APC of traditional smoked chali found4.40 x 10^4, 1.62 x 10^4 and 8.80 x 10^3 CFU/gin non-sealed, air tight and vacuum sealed packs, respectively which increased to 3.16 x 10^7, 2.07 x 10^6 and 3.10 x 10^5 CFU/g after storage period of 120 days at room temperature. In the case of improved smoked chali, chaka, horina and khogda also a similar increasing trend in aerobic plate count of bacteria was followed (Table-5). Among different smoked shrimp samples aerobic plate count of bacteria were found 1.72 x 10^4, 8.50 x $10^3$and 1.30 x 10^3 CFU/g of non-sealed, air tight and vacuum sealed improved smoked chaka on 15th day of storage, with the progress of storage period aerobic plate counts of these samples increased to 1.18 x 10^7, 6.20 x 10^5 and 2.24 x 10^5 CFU/g on storage date of 90indicating the slower rate of increase in APC count of the smoked shrimp samples both in air tight and vacuum sealed packs.

The results obtained in the present study are in agreement with findings of Hoq *et al*. (2003). They studied the nutritional qualities of smoked shrimp from the Sundarbans mangrove area, Bangladesh. In their 90 days of storage quality study the found that, moisture level increased to 24% from initial 13% and the protein content of raw shrimp was 14.51%, after smoking the protein content found to be 68.08% due to loss of about 60% moisture. After one month storage protein content reduced to 64.48%. The protein percentage further reduced to 57.17% after 60 days and at 90th day it stands at 52% due to gradual increase of moisture content. Lipid content gradually increased to 11.66% from 6.88%. Proximate composition and bacterial load study in market sample revealed increased moisture level (19.51%) and decreased protein content (60.83%) with a microbial load of 6.5x10^4cfu/g. Total volatile base nitrogen (TVBN) value increased with storage time from 22.75% at "0"day to 29.33% at 90thday. Total bacterial counts of the smoked product increased to 1.41x10^7cfu/g from an initial 2.46x10^4cfu/g over 90 days.

Haq *et al*. (2008) carried out a comparative study on the shelf life of smokes shrimp products in different storage conditions, which was quite similar to the present study. The study was performed at room temperature (28~30°C) and the smoked shrimp (Chali; *Metapeneous brevicornis*) was stored at polythene bag, gunny bag and hogla made basket. Different quality parameters of smoked shrimps were studied for 4 months at 15 days interval. In their 4 months study, moisture level increased from 11.87±0.51 to 25.48±0.28, 26.53±0.12and 29.41±0.25 % in polythene bag, gunny bag and hogla made basket, respectively. The protein content reduced from 66.08±0.76 to 51.32 ±0.26, 51.89±0.42 and 46.80±0.50% in three above mentioned bags. Lipid content also gradually decreased from9.43±0.65 to 9.35 ±0.41, 9.13±0.51 and 8.98±0.46%. Total volatile base nitrogen (TVB-N) value increased with the lapse of storage time from 13.42 to 28.60, 32.45 and 34.06.

Chakroborty and Chakraborty (2017) studied the effect of storage temperature on the quality and microbial content of salt-smoke-dried shoal (*Ophiocephalus striatus*). The fish in three treatments T1, T2 and T3 were denoted controlled, ambient (22-28°C) and refrigeration (4°) condition, respectively. From the study it was found that the moisture, ash, protein and lipid, was 27.05%, 11.81%, 50.09%, 8.64% and 2.96 × 104 CFU/g for treatment T1. The same parameters during 30 days observation for treatment T2 ranged from 25.09-25.41%, 13.92-15.98%, 54.07-51.74% and 5.94-5.81%, respectively whereas during 45 days observation for treatment T3 25.09-25.57%, 13.92-15.98%, 54.07-52.49% and 5.94-5.82%, respectively. Analyzing all the quality parameters of the salt-smoke-dried shoal it was revealed that the quality was still excellent and no indicative quality reduction occurred in shoal kept at refrigeration temperature (treatment T3) during 45 days of storage. These values are quite nearer to the values obtained in the present study for smoked shrimp.

Table 5. Changes in the biochemical and microbiological parameters of smoked shrimps during storage at room temperature (28 to 32°C) in different packs

Sample name	Packing condition	Days of storage	*Changes in biochemical and microbiological parameters*					
			Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	APC (CFU/g)
Improved smokedChali	Non sealed pack	0	17.53±0.11	61.18±0.91	9.24±0.05	12.52±0.09	15.83±0.08	3.6 0 x 10^3
		15	19.94±0.12	58.42±0.34	8.75±0.04	14.52±0.05	18.69±0.09	4.40 x 10^4
		30	22.00±0.09	54.15±0.44	8.24±0.03	14.92±0.15	23.36±0.11	8.20 x 10^5
		60	26.75±0.12	48.98±0.54	7.79±0.08	16.36±0.08	29.84±0.12	1.06 x 10^7
		90	29.32±0.07	44.78±0.22	6.27±0.10	18.06±0.10	32.44±0.10	4.88 x 10^7
		120	32.88±0.21	40.66±0.34	5.34±0.09	19.11±0.07	35.33±0.12	2.14 x 10^8
	Air tight pack	15	18.95±0.11	59.39±0.66	9.11±0.02	13.02±0.05	17.73±0.11	1.62 x 10^4
		30	20.04±0.12	58.04±0.28	8.76±0.05	13.81±0.09	20.26±0.07	9.70 x 10^4
		60	20.0810.07	55.47±0.61	8.62±0.05	14.72±0.07	24.85±0.09	7.90 x 10^5
		90	21.42±0.09	53.14±0.24	7.88±0.07	15.53±0.09	30.15±0.10	5.80 x 10^6
		120	22.75±0.12	50.18±0.21	6.79±0.08	16.46±0.06	34.84±0.12	3.42 x 10^7
	Vacuum sealed pack	15	17.55±0.12	60.21±0.45	9.18±0.03	13.18±0.06	17.12±0.10	8.80 x 10^3
		30	17.67±0.13	59.13±0.45	9.02±0.06	13.52±0.12	19.34±0.05	2.93 x 10^4
		60	17.84±0.12	57.84±0.54	8.80±0.04	14.70±0.06	22.33±0.10	1.71 x 10^5
		90	18.27±0.13	54.91±0.39	8.35±0.06	15.04±0.06	25.72±0.11	8.50 x 10^5
		120	18.83±0.21	52.88±0.51	7.94±0.06	15.89±0.11	29.28±0.21	2.87 x 10^6
Improved smokedChali	Non sealed pack	0	14.22±0.02	64.05±0.41	9.85±0.04	11.06±0.05	12.23±0.11	4.30 x 10^2
		15	15.79±0.13	62.12±0.54	9.66±0.04	11.94±0.09	15.06±0.08	2.81 x 10^3
		30	18.53±0.13	59.46±0.53	9.32±0.04	13.26±0.05	17.79±0.08	3.30 x 10^4
		60	21.87±0.13	54.51±0.27	8.73±0.06	14.48±0.04	23.16±0.14	6.30 x 10^5
		90	26.56±0.20	48.32±0.41	8.82±0.06	15.97±0.13	*29.28±0.13*	3.60 x 10^6
		120	30.75±0.12	43.28±0.24	7.66±0.05	16.46±0.07	*33.64±0.10*	2.06 x 10^7
	Air tight pack	15	15.17±0.12	63.78±0.52	9.79±0.04	11.61±0.08	*13.24±0.09*	1.59 x 10^3
		30	16.45±0.14	61.98±0.52	9.58±0.05	12.47±0.07	*15.88±0.09*	*4.60 x 10^3*
		60	17.68±0.12	58.74±0.42	9.44±0.06	13.44±0.09	*19.76±0.12*	*3.20 x 10^4*
		90	18.09±0.11	56.88±0.52	8.83±0.07	14.38±0.04	*23.90±0.11*	*2.92 x 10^5*
		120	18.68±0.12	54.73±0.38	8.02±0.07	15.21±0.04	*29.02±0.12*	*7.80 x 10^5*
	Vacuum sealed pack	15	14.24±0.11	63.32±0.39	9.81±0.08	11.72±0.04	*12.95±0.10*	*8.40 x 10^2*
		30	14.29±0.12	62.73±0.55	9.76±0.06	12.15±0.07	*14.50±0.12*	*2.02 x 10^3*
		60	14.39±0.12	61.49±0.51	9.62±0.07	12.84±0.09	*17.83±0.10*	*9.40 x 10^3*
		90	14.78±0.15	59.85±0.61	9.12±0.05	13.35±0.09	*21.05±0.13*	*4.10 x 10^4*
		120	15.12±0.13	57.61±0.84	8.66±0.05	14.28±0.08	*24.54±0.09*	*2.12 x 10^5*
Improved smoked Chaka	Non sealed pack	0	16.02±0.03	62.15±0.54	9.96±0.06	11.79±0.07	14.05±0.13	2.05 x 10^3
		15	17.35±0.12	60.15±0.36	9.73±0.05	12.58±0.07	16.82±0.12	1.72 x 10^4
		30	19.22±0.15	58.01±0.55	9.49±0.06	12.98±0.06	19.73±0.13	1.05 x 10^5
		60	23.81±0.14	54.14±0.45	9.09±0.03	14.94±0.04	24.36±0.14	1.21 x 10^6
		90	28.68±0.15	48.12±0.54	7.96±0.05	16.13±0.13	30.83±0.13	1.18 x 10^7
		120	31.55±0.12	44.23±0.31	6.58±0.07	18.36±0.09	34.87±0.13	1.13 x 10^8
	Air tight pack	15	16.90±0.13	60.92±0.32	9.88±0.06	12.25±0.05	15.11±0.09	8.50 x 10^3
		30	18.10±0.15	59.83±0.41	9.76±0.04	13.02±0.05	18.05±0.12	2.76 x 10^4
		60	19.22±0.13	57.58±0.47	9.58±0.04	13.45±0.07	21.48±0.11	1.86 x 10^5
		90	20.04±0.13	55.21±0.62	9.01±0.07	14.76±0.06	25.55±0.12	6.20 x 10^5
		120	20.67±0.12	53.01±0.36	8.26±0.08	15.47±0.08	30.04±0.12	2.57 x 10^6
	Vacuum sealed pack	15	16.05±0.11	61.77±0.62	9.94±0.01	12.31±0.06	14.78±0.11	1.30 x 10^3
		30	16.04±0.11	60.94±0.51	9.82±0.03	12.74±0.06	16.72±0.08	1.59 x 10^4
		60	16.14±0.11	59.72±0.24	9.70±0.05	13.32±0.09	19.84±0.15	3.80 x 10^5
		90	16.47±0.06	57.89±0.29	9.33±0.05	13.96±0.04	23.45±0.12	2.24 x 10^5
		120	17.09±0.22	55.98±0.42	9.15±0.04	14.41±0.08	26.62±0.15	5.20 x 10^5
Improved Smoked Horina	Non sealed pack	0	15.36±0.05	63.70±0.55	10.05±0.06	11.38±0.08	12.86±0.07	9.80 x 10^2
		15	16.95±010	61.97±0.54	9.84±0.04	12.34±0.05	15.96±0.09	3.70 x 10^3
		30	19.66±0.11	58.10±0.52	9.68±0.05	13.55±0.04	18.78±0.12	4.30 x 10^4
		60	23.37±0.11	55.04±0.65	9.05±0.06	14.97±0.07	23.84±0.12	7.40 x 10^5
		90	28.57±0.11	48.75±0.64	8.58±0.02	16.32±0.04	29.36±0.17	9.10 x 10^6
		120	31.65±0.04	45.44±0.33	7.76±0.08	18.36±0.08	32.84±0.11	2.46 x 10^7
	Air tight pack	15	16.11±0.16	62.15±0.57	9.97±0.05	11.82±0.02	14.48±0.10	2.49 x 10^3
		30	17.38±0.13	61.04±0.54	9.85±0.03	12.66±0.03	17.34±0.12	7.20 x 10^3
		60	18.72±0.09	58.46±0.29	9.62±0.05	13.44±0.06	20.05±0.14	3.60 x 10^4
		90	19.56±0.12	55.23±0.54	9.11±0.04	14.87±0.05	24.62±0.15	2.75 x 10^5
		120	20.49±0.11	53.11±0.55	8.54±0.04	15.45±0.04	29.89±0.12	9.80 x 10^5
	Vacuum sealed pack	15	15.40±0.08	62.89±0.51	9.99±0.04	11.71±0.09	13.97±0.08	1.67 x 10^3
		30	15.42±0.09	62.06±0.56	9.95±0.05	12.35±0.04	15.42±0.15	2.95 x 10^3
		60	15.61±0.12	60.37±0.27	9.81±0.04	13.62±0.05	18.70±0.11	1.22 x 10^4
		90	15.92±0.11	58.26±0.41	9.54±0.04	14.45±0.08	22.15±0.12	5.40 x 10^4
		120	16.49±0.15	56.05±0.51	9.10±0.06	15.06±0.06	25.94±0.14	2.87 x 10^5

Table5. Contd.

Improved Smoked Khogda	Non sealed pack	0	16.15±0.12	63.11±0.41	9.73±0.06	12.14±0.04	13.14±0.10	1.12 x 10^3
		15	17.84±0.12	60.62±0.31	9.37±0.06	12.88±0.05	16.42±0.04	7.50 x10^3
		30	20.47±0.15	59.55±0.41	9.05±0.03	13.71±0.04	19.26±0.12	5.80 x 10^4
		60	23.56±0.10	54.88±0.44	8.52±0.06	14.45±0.05	24.12±0.12	8.50 x 10^5
		90	26.75±0.12	49.10±0.56	7.68±0.05	15.96±007	30.17±0.14	7.80 x 10^6
		120	29.85±0.16	45.35±0.44	6.74±0.07	16.56±0.07	35.14±0.12	3.16 x 10^7
	Air tight pack	15	16.97±0.12	61.83±0.29	9.58±0.05	12.49±0.07	15.16±0.03	2.73 x 10^3
		30	17.89±0.12	60.69±0.52	9.42±0.05	13.61±0.04	17.12±0.09	8.50 x 10^3
		60	18.58±0.11	58.92±0.34	9.03±0.05	13.68±0.05	20.60±0.09	5.10 x 10^4
		90	19.77±0.08	55.94±0.61	8.66±0.03	14.52±0.09	25.25±0.08	3.30 x 10^5
		120	20.21±0.11	52.78±0.41	7.98±0.05	15.45±0.06	30.52±0.20	2.07 x 10^6
	Vacuum sealed pack	15	16.14±0.13	62.34±0.26	9.69±0.04	12.42±0.05	14.59±0.05	1.68 x 10^3
		30	16.17±0.14	61.25±0.39	9.62±0.04	12.86±0.04	16.66±0.08	2.81 x 10^3
		60	16.19±0.13	60.17±0.62	9.48±0.04	13.39±0.06	19.91±0.10	1.35 x 10^4
		90	16.51±0.09	58.00±0.46	9.01±0.04	14.00±0.08	22.96±0.13	7.80 x 10^4
		120	17.11±0.13	56.36±0.52	8.55±0.04	14.58±0.05	25.88±0.15	3.10 x 10^5

Conclusion

From the obtained results present study could be concluded as- in all respect quality of the smoked shrimps prepared in laboratory was better than traditional one and smoked shrimps can be stored in air tight pack and vacuum packs in ambient temperature for 120 days or more without significant quality loss. Improved smoked shrimp showed the longer shelf-life compared to the traditional smoked shrimps. Significant reduction of the moisture level of the smoked shrimp increase the shelf life of the smoked shrimp products.

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