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Quality Changes of Salt-Smoke-Dried Tengra (*Mystus tengara*) during Storage at Room Temperature (28 To 32°C) in Different Packs

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Abstract
Packing has effect on the quality parameters of a food product. Here, studies were conducted to produce premium quality salt-smoke-dried tengra fish (*Mystus tengra*) by combining the effect of salt and smoke in a smoking kiln. During the study, moisture content in tengra fish fell from an initial value of 77.17% to a range of 18.56% to 29.09%, protein content from 51.36% to a range of 40.54% to 51.36%, lipid content from 16.20% to a range of 6.50% to 16.20% and ash content from 13.40% to a range of 8.17% to 13.40% for salt-smoke-dried products at the end of the storage period. On the other hand, the TVB-N value of fresh fish muscle was obtained 2.90 (mg/100g), pH 6.80 and bacterial load 1.13×10^4 (CFU/g), with the progress of storage period 180 days which values increased to the range of 28.16 to 29.34 mg/100g, 6.27 to 7.86 and 4.42 $\times10^5$to 6.82 x 10^5CFU/g, respectively. From the obtained results this study could be concluded that- if tengra is salted, smoked and dried properly can be stored at room temperature (26 to 28°C) for about 6 months without major deterioration of the fish and among three packs vacuum pack might be better option for storing salt-smoke-dried tengra.

Key words: Packing, Quality change, Room temperature, Salt-smoke-dried tengra, Storage

Introduction

For fish preservation, curing is an age old method. By curing fish its shelf life can be extended. The methods like- drying, salting, smoking are based on the principle of the reduction of moisture from fish muscle. In curing process the water activity (a_w) is decreased. There are a number of advantages and disadvantage of each type of preservation method. Of all food preservation methods, drying has received the most widespread and enthusiastic publicity in recent years (Calicioglu *et al.,* 2002). Salting is another method of curing for fish preservation. Dry-salting process is considered as one of the oldest methods of fish preservation and this process is still been used in several places around the world. The aim of dry-salting is not only to prolong the shell life of fresh fish but also to provide desirable sensorial changes (Ahmed *et al.*, 1981; Andres *et al.*, 2005). The role of salt is highly significant to guarantee the quality and stability of the finished products. The preservative action of salt lies in the reduction of water activity of a system thus renders a condition less favorable for the microbial life (Barbut *et al.*, 1986; Luck and Jager, 1997). Smoking is a method of preserving fish which involves cooking, drying, and smoking (Clucas and Ward, 1996). This method combines six important effects in fish and shrimp muscle. Fire producing smoke can generate heat and dry the fish and thus reduce the water activity so that the microorganisms cannot survive. Hot smoking cooks the flesh and thus destroys enzymes and kills the bacteria. Wood smoke contains compound like phenol which kills bacteria. Besides, wood smoke gives highly relished characteristic smoke flavor (Horner, 1992).

According to Rahman (1989), there are 260 species of freshwater indigenous fishes in Bangladesh. Felts et al. (1996) have included 45 fish species on the list of SIS including carps and minnows (18 species), catfishes (9 species), perches (9 species). Tengra (*Mystus tengara*) is one of the most common catfish of the commercial catches of Bangladesh. People of the country are being acquainted with different fish products with time. Testing of some smoke cured, salt smoke cured, salt dried fish with native species prepared experimentally showed the consumer's preference for this tasty product as encouraging (Salim *et al.*, 2007). For developing different fish products of having better quality in comparison to the fish products available in the market, attempts need to be taken with the available fish species. Changes in their nutritive value, quality parameters should be tested at different storage condition for the availability of these product round the year by consumers. Therefore, considering the possible health benefit or risk and the nutritional benefits associated with fish consumption; this study was carried out to ascertaining the effect of salt-smoke-drying on the nutritional, biochemical and microbiological parameters of tengra (*Mystus tengara*) during storage at room temperature (28 to 32°C) in three packing condition.

Materials and Methods

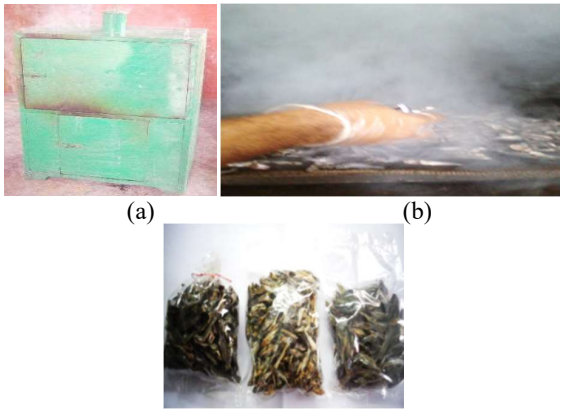
Here, for the experiment, high quality salt treated smoked-dried product was prepared. Samples were stored in three different packs like- tied, sealed and vacuum sealed. The quality of the products was determined by biochemical and bacteriological evaluations.

Experimental design

For the experiment fresh tengra (*Mystus tengara*) was collected from the K.R. market near Bangladesh Agricultural University (BAU) campus, Mymensingh. Drying was conducted using solar tunnel dryer of the Department of Fisheries Technology. Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. The experiment on salting-smoking-drying and analysis were carried out from the month of February to August, 2016.

Description of smoking kiln

Improved traditional type of smoking kiln was used (Debnath *et al.*, 2009) to generate smoke which was more or less similar with the design of kilns based on to the Torry kiln developed by the Torry Research Station in Aberdeen, Scotland (FAO Fisheries Technical Report,no.88 and the FAO Fisheries Technical paper, no. 104; 1971). The smoking kiln or smoking chamber was made with steel as a rectangular box of 105×75×45 cm3 size (Plate 1.a). Horizontally, the box or chamber was divided into two equal parts by using a horizontal perforated iron net frame and the bottom portion was used as base for burring saw dust as smoke source. The upper chamber had facilities of hanging 4-6 mm 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 fish chamber i.e. the upper chamber could be controlled. Another small hole on the top was used to provide a sensitive thermometer to measure the temperature inside the chamber. Smoking was achieved by burning of wood saw dust. The moderately hot smoke (temperature 55°C) arose through the big hole into the upper chamber where fish fillets were hung separately. The saw dust used for smoke was made of black berry (*Syzygiumcumini*) tree and was collected from a local saw-mill. The saw dust was made semi-dried before using in the kiln for easy burning. Some small piece of woods was also used for supporting the fire of sawdust.



(a) (b)

(c)

Plate 1. (a) Smoking kiln; (b) Smoking of fish in smoking kiln and (c) Salt-smoke-dried fishes in different packs

The experimental process

For the preparation of salt-smoke-dried product fresh tengra (*Mystus tengara)* were collected from K.R. market of Bangladesh Agricultural University (BAU) campus, Mymensingh. The collected fresh fish samples were carried on the laboratory of Department of Fisheries technology, Bangladesh Agricultural University tin ice stored condition, For the study 7 kg fresh tengra fish were collected. The procedure for the preparation of salt-smoke-dried fish products is presented in Figure 1.

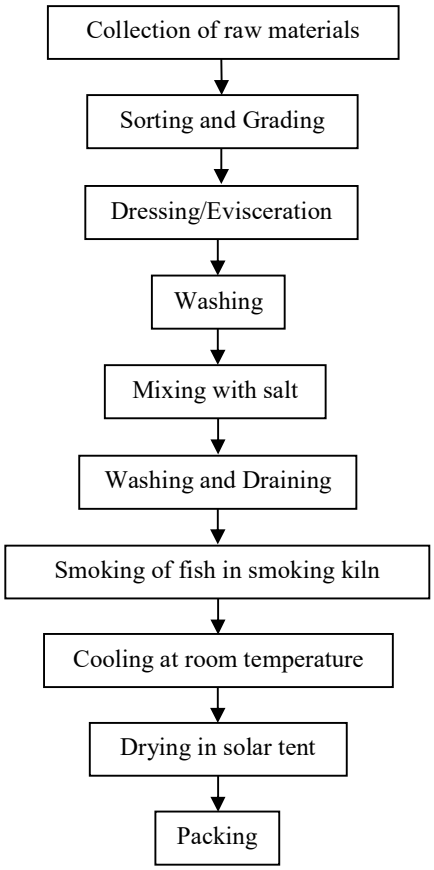


Fig. 1. Processing steps of salt-smoke-dried tengra preparation

Quality assessments of salt-smoke-dried tengra

For chemical analysis, whole dried fish samples were ground in an electric blender to produce a homogenous one before being sampled for analysis. Samples of each treatment were packed in polythene bags tightly by using a sealer and kept for further analysis.

Proximate composition

Proximate composition analysis of percent moisture, ash, crude protein and lipid contents of salt-dried tengra samples were carried out according to the methods as given in AOAC (2000) with certain modification.

Total Volatile Base Nitrogen (TVB-N)

Total Volatile Base Nitrogen (TVB-N) was determined according to the methods given in AOAC (2000).

Determination of pH value

pH was measured at room temperature following the method described by AOAC (2005). At first accurately 5g sample was taken and homogenously mixed in 50 ml distilled water. pH was measured using an electronic pH meter (HANNA pH 211 Microprocessor pH Meter) with a glass electrode using expandable scale.

Aerobic plate count (APC)

Aerobic plate count of the samples was done by spread laboratory as per direction of Cowan and Steel's Manual for the Identification of Medical Bacteria (Barrow and Felthham, 1993) and with the help of DIFCO, Manual of Dehydrated Culture Media and Reagents, 9th edition, 1964. Number of bacteria per gram of the fish sample (CFU/g) was calculated by using the following formula:

$$\text{CFU/g} = \frac{\text{No. of colonies on Petridish} \times 10 \times \text{dillusion factor} \times \text{volume of total sample soln.}}{\text{wt. of fish sample (gm)}}$$

Data analysis

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

Results and Discussion

Proximate composition, TVB-N and pH of fresh tengra (Mystus tengara)

Nutrient value of a particular fish is understood by the analyzing proximate composition that fish. Proximate composition analysis helps to make a decision on the necessity of processing or preservation of fish. Between moisture and lipid content of fish, there is an inverse relationship. In fresh fish moisture content is always high. TVB-N and pH are the indicator of freshness of fish. TVB-N indicates the presence of total volatile base nitrogen as mg/100g. pH indicates alkalinity and acidity. pH of fresh fish is around neutral. Chemical composition of fresh tengra is shown in Table 1. For fresh tengra, Latifa *et al.* (2014) found that the percentage of moisture, protein, fat, ash was 74.27%, 13.43% 9.04% and 2.67% and TVB-N and pH was 4.27mg/100g and 7, respectively. In the present study the values of moisture, protein, lipid and ash contents were found 75.87%, 13.86%, 7.21% and 2.75% and TVB-N and pH values were obtained 2.90mg/100g and 6.80, respectively which were quite nearer with above study.

Table 1. Proximate composition, TVB-N and pH values of fresh tengra (*Mystus tengara)*

Parameters	Values
Moisture (%)	75.87±0.19
Protein (%)	13.86±0.06
Lipid (%)	7.21±0.09
Ash (%)	2.75±0.11
TVB-N (mg/100g)	2.90
pH	6.80

Changes in the proximate composition, TVB-N and pH values in salt-smoke-dried tengra stored in different packs

Packaging of fish product is very important to extend the shelf-life of the products. Packing protects the product from contamination and prevent it from spoilage, and at the same time it facilitates distribution and display, give the product greater consumer appeal. In this experiment three types of packs (tied, sealed and vacuum sealed pack) were used.

Changes in proximate composition

Moisture content (%)

The moisture content of fresh tengra was found 75.87±0.19% (Table1). After salting-smoking-drying, the moisture content of salt-dried-smoked tengra decreased and on "0" day the value obtained18.56±0.06%. The changes in moisture content of salt-dried-smoked tengra stored at room temperature (28 to 32°C) in three different packs are presented in Table 2.The table shows that- during storage of 180 days moisture content gradually increased in the salt-smoke-dried tengra from the value of "0" day, irrespective of packing condition. Though the increasing trend in moisture content (%) was observed in three types of packing but moisture intake was slightly higher in tied pack than sealed and vacuum sealed packs. After 60 days of storage of salt-smoke-dried tengra the moisture contents (%) were found 20.11±0.13, 21.16±0.12 and 20.98±0.01% in tied, sealed and vacuum sealed packs, respectively which increased to 23.12±0.19, 24.96±0.03 and 23.78±0.23% after 120 days storage and finally reached to 29.09±0.24, 27.66±0.19 and 26.88±0.15% after storage of 180 days at room temperature.

Protein content (%)

In fresh fish, the protein content (%) was found 13.86±0.06%. After preparation of salt-smoke-dried tengra, protein content value reached to 51.36±0.08% on "0" day. The changes in protein content (%) of salt-smoke-dried tengra in different packs stored at room (28 to 32°C) temperature is presented in Table 2. Table shows that- percent protein content of salt-smoke-dried tengra decrease with the increase of storage period in all types of packs After 60 days of storage the values were decreased to 47.95±0.21, 48.26±0.11 and 47.54±0.05% in tied, sealed and vacuum sealed packs, respectively. While the salt-smoke-dried tengra stored for 120 days the values were found 44.75±0.03, 44.81±0.17 and 45.60±0.08 % and at the end of experiment of 180 days the values reduced to 40.54±0.06, 42.90±0.09 and 43.40±0.14%, respectively.

Table 2. Changes in proximate composition (%) of salt-smoke-dried tengra (*Mystus tengara)* in different packs during storage at room temperature (28 to 32°C)

Days	Moisture content (%)			Protein content (%)			Lipid content (%)			Ash content (%)		
	Tied pack	Sealed pack	Vacuum sealed pack	Tied pack	Sealed pack	Vacuum sealed pack	Tied pack	Sealed pack	Vacuum sealed pack	Tied pack	Sealed pack	Vacuum sealed pack
0	18.56 ± 0.06	18.56 ± 0.06	18.56 ± 0.06	51.36 ± 0.08.	51.36 ± 0.08	51.36 ± 0.08	16.20 ± 0.11	16.20 ± 0.11	16.20 ± 0.11	13.40 ± 0.04	13.40 ± 04	13.40 ± 0.04
15	18.81 ± 0.07	-	-	50.98 ± 0.13	-	-	16.01 ± 0.06	-	-	13.16 ± 0.03	-	-
30	19.01 ± 0.30	19.11 ± 0.12	-	50.60 ± 0.09	50.91 ± 0.12	-	15.75 ± 0.05	15.66 ± 0.23	-	13.06 ± 0.07	13.08 ± 0.07	-
45	19.71 ± 0.03	-	-	49.50 ± 0.23	-	-	15.14 ± 0.03	-	-	12.44 ± 0.06	-	-
60	20.11 ± 0.13	21.16 ± 0.12	20.98 ± 0.01	47.95 ± 0.21	48.26 ± 0.11	47.54 ± 0.05	14.59 ± 0.13	14.50 ± 0.24	14.58 ± 0.14	12.20 ± 0.14	12.21 ± 0.03	12.30 ± 0.11
75	21.01 ± 0.16	-	-	47.26 ± 0.04		-	13.89 ± 0.12	-	-	11.77 ± 0.07	-	-
90	21.96 ± 0.08	22.86 ± 0.06	-	46.33 ± 0.21	46.16 ± 0.13	-	13.14 ± 0.11	13.57 ± 0.06	-	11.31 ± 0.13	11.01 ± 0.06	-
105	22.52 ± 0.07	-	-	45.62 ± 0.26		-	11.84 ± 0.03	-	-	10.95 ± 0.23	-	-
120	23.12 ± 0.19	24.96 ± 0.03	23.78 ± 0.23	44.75 ± 0.03	44.81 ± 0.17	45.60 ± 0.08	11.37 ± 0.04	12.38 ± 0.04	12.48 ± 0.08	10.57 ± 0.27	10.22 ± 0.13	11.22 ± 0.08
135	24.47 ± 0.14	-	-	43.55 ± 0.07	-	-	10.17 ± 0.15	-	-	10.12 ± 0.12	-	-
150	25.04 ± 0.19	26.36 ± 0.07	-	43.13 ± 0.13	43.83 ± 0.12	-	8.67 ± 0.14	11.18 ± 0.05	-	9.18 ± 0.16	9.67 ± 0.08	-
165	26.79 ± 0.07	-	-	41.88 ± 0.14	-	-	7.42 ± 0.24	-	-	8.64 ± 0.11	-	-
180	29.09 ± 0.24	27.66 ± 0.19	26.88 ± 0.15	40.54 ± 0.06	42.90 ± 0.09	43.40 ± 0.14	6.50 ± 0.05	10.35 ± 0.16	10.96 ± 0.06	8.17 ± 0.04	8.92 ± 0.06	9.66 ± 0.06

Lipid Content (%)

Lipid content was found 7.21±0.09% (Table1) in fresh fish. After preparing the salt-smoke-dried tengra the lipid content increased and on "0" day of storage the value was obtained16.20±0.11%. The changes in lipid content of salt-smoke-dried tengra in different packs stored at room temperature are presented in Table 2. From the table it was observed that- percent lipid content gradually decreased in the salt-smoke-dried tengra in all packs throughout the storage of 180 days. In all three types of packing though a decreasing trend in lipid content (%) was observed, the values were comparatively lower in tied pack samples than sealed and vacuum sealed pack samples. The lipid contents (%) were found 14.59±0.13, 14.50±0.24 and 14.58±0.14% in tied, sealed and vacuum sealed packs, respectively after 60 days of storage of salt-smoke-dried tengra which further decreased to 11.37±0.04, 12.38±0.04 and 12.48±0.08% after 120 days of storage and after storage of 180 days finally values reduced to 6.50±0.05, 10.35±0.16 and 10.96±0.06%.

Ash content (%)

The ash content was found 2.75±0.11% (Table1) in fresh tengra. After preparing salt-smoked-dried tengra ash content increased. On "0" day of storage, the ash content was obtained13.40±0.04% in salt-smoke-dried tengra. The changes in ash content of salt-smoke-dried tengra in different packs stored at room temperature are presented in Table 2. The table shows that-in all the salt-smoke-dried tengra, stored in three different packs-ash content decreased throughout the storage period of 180 days. After 60 days of storage the ash contents (%) of salt-smoke-dried tengra were obtained12.20±0.14, 12.21±0.03 and 12.30±0.11% in tied, sealed and vacuum sealed packs, respectively which decreased to 10.57±0.27, 10.22±0.13 and 11.22±0.08% after 120 days of storage and finally reduced to 8.17±0.04, 8.92±0.06 and 9.66±0.06% after storage of 180 days at room temperature.

Findings of the present study are quite similar to the results of Nahid *et al*. (2015). They carried out a study on proximate composition of salted smoke-dried and salt-garlic treated smoke-dried chapila (*Gudusia chapra*) fish stored at room temperature. In salt treated smoke-dried chapila (S-C), moisture, crude protein, lipid and ash contents were found 5.31%, 46.47%, 29.05% and 19.92% respectively. The same parameters were 6.77%, 45.24%, 30.52% and 18.71% respectively in case of salt-garlic treated smoke-dried chapila (S+G-C) fish. During storage at room temperature (26-32°C), the percentage of moisture was increased significantly whereas crude protein, lipid and ash contents were decreased. The values of moisture (%) content were increased 9.91% (8^{th} month) in S-C and 10.74 % (16^{th} month) in S+G-C respectively. The values of protein (%) content were decreased 44.81% (8^{th} month) in S-C and 42.66% (16^{th} month) in S+G-C respectively. Values of fat and ash (%) content were decreased 28.55% and 18.01% (8^{th} month) respectively in S-C and 28.75% and 17.34% (16^{th} month) respectively in S+G-C. The overall study showed that the smoke cured fish treated with salt-garlic had longer shelf life and found better for preservation.

Latifa *et al*. (2014) carried out a comparative study of quality-analysis of three different Bangladeshi smoke-dried lean fishes using salt and turmeric stored at refrigeration temperature (4°C). The differences in the biochemical composition of the fresh and smoke-dried samples were statistically significant ($p<0.05$). Moisture (%) value (mgN/100gm) increased significantly whereas protein(%), lipid (%) and ash(%) content significantly decreased. The initial value of moisture, protein, lipid, ash of freshly smoke-dried Chapila, Kaika and Guchi-Baim fish was 6.21%, 45.93%, 30.81%, 18.95%; 8.24%, 63.04%, 6.71%, 22.52% and 6.97%, 59.22%, 11.67%, 22.54%, respectively. Among these three fish species smoke-dried kaika fish product became spoiled at the end of 9months whereas smoke-dried Chapila and GuchiBaim fish product still remain in good condition. The shelf-life of smoke-dried Chapila and GuchiBaim fish product was 18 month and 27 month. Because of using salt and turmeric as natural preservative, no yeast or mould was detected in this three smoke-dried fish samples. The effect of salt observed in their study is quite similar to the present study.

The results of the present study is in agreement with the findings of Rana *et al.* (2019) who carried out an investigation on the changes in sensory attributes, proximate composition analysis and microbiological components of salt-smoke-dried (SSD) products prepared from two different SIS such as tengra (Mystustengara) and batashi (*Neotropius atherinoides*) during storage at ambient (26-28°C) and refrigeration (4°C) temperature. Organoleptically, the quality of SSD products stored (60 days) at refrigeration temperature was better than stored at ambient temperature. During storage periods (60 days), the moisture content of fresh tengra was 76.06% whereas 18.80 and 18.36% for SSD and CD respectively. Fresh tengra had 13.45% protein, 7.46% lipid and 2.80% ash. The initial value of protein, fat and ash content of SSD tengra was 63.40, 19.95 and 16.55% respectively on dry matter basis. During 60 days storage period moisture increased whereas protein, fat, and ash content decreased considerably. After two month storage at ambient temperature the protein, lipid and ash content for SSD tengra were 62.75, 19.07 and 15.99% respectively whereas the values of the same parameters stored at refrigeration temperature were 62.54, 19.54 and 16.12% respectively on dry matter basis.

Changes in biochemical parameters

TVB-N value

Total Volatile Base Nitrogen (TVB-N) is widely used as an indicator of the degree of lipid oxidation (Daramola *et al.*, 2013). The TVB-N value of fresh tengra was 2.90 (Table 1). After salting-smoking-drying of tengra the TVB-N value increased to 4.10 mg/100g (Table 3). During 180 days of storage the increasing trend in TVB-N values continued. The changes in TVB-N value (mg/100g) of salt-smoke-dried tengra stored at room temperature in different packs are presented in Table 3. The table shows that-the TVB-N values increased in all the salt-smoke-dried tengra stored for 180 days in three different packs. The TVB-N value of salt-smoke=dried tengra were found 17.28, 17.22 and 17.29 (mg/100g)in tied, sealed and vacuum sealed packs, respectively which further increased to 23.65, 23.57 and 23.61 (mg/100g) after 120 days of storage and finally reached to 29.94, 29.20 and 29.37 (mg/100 g) after storage of 180 days at room temperature.

Table 3. Changes in TVB-N content (mg/100g) and pH of salt-dried (SD) tengra (*Mystustengara)* in different packs stored at room temperature (28 to 32°C)

Days	TVB-N content ((mg/100g)			pH		
	Tied pack	Sealed pack	Vacuum sealed pack	Tied pack	Sealed pack	Vacuum sealed pack
0	4.10	4.10	4.10	6.27	6.27	6.27
15	9.40	-	-	6.32	-	-
30	12.35	12.39	-	6.39	6.35	-
45	15.17	-	-	6.45	-	-
60	17.28	17.22	17.29	6.60	6.60	6.55
75	19.34	-	-	6.72	-	-
90	20.95	20.89	-	6.80	6.85	-
105	21.30	-	-	6.94	-	-
120	23.65	23.57	23.61	7.10	7.18	7.20
135	25.45	-	-	7.22	-	-
150	26.88	26.76	-	7.35	7.40	-
165	28.67	-	-	7.50	-	-
180	29.94	29.20	29.37	7.86	7.83	7.65

The TVB-N value results of the present study are quite nearer to the values reported by Rana *et al.* (2019). In their investigation with salt-smoke-dried tengra (Mystustengara) and batashi (*Neotropius atherinoides*) at ambient (26-28°C) and refrigeration (4°C) temperature the TVB-N values varied between 5.86 (0 day) to 18.21 mg/100g (60 day) for salt-smoke-dried tengra, 6.88 (0 day) to 21.20 mg/100g (60 day) for control dried tengra, 6.14 (0 day) to 17.94 mg/100g for salt-smoke-dried batashi, 7.05 (0 day) to 19.42

mg/100g (60 day) for control dried batashi, respectively. Although, the TVB-N value for SSD and CD after two month storage was in the range of 11.81 to 18.21, 15.08 to 21.20, 11.20 to 17.94 and 12.84 to 19.42 mgN/100g for SSD tengra, CD tengra, SSD batashi and CD batashi, respectively, the values are within the acceptable limit as Connell (1995) reported and also recommended the limit of acceptability of fish is 20 to 30 mg N/100 g. Pearson (1982) also recommended the limit of acceptability of TVBN in fish is 20 to 30 mgN/100 g, while Kirk and Sawyer (1991) suggested a value of 30 to 40 mgN/100 g as the upper limit for fish

pH value

The pH value of fresh tengra was found 6.80 (Table 1). After preparing the salt-smoke-dried tengra the pH value decreased to 6.27 mg/100g (Table 3) which further increased gradually. During 180 days of storage this increasing trend continued. The changes in pH value (mg/100g) of salt-smoke-dried tengra stored at room temperature in different packs are presented in Table 3. The table shows that-the pH value increased in all the salt-smoke-dried tengra stored for 180 days. The pH value of salt-smoke-dried tengra were found 6.60, 6.60 and 6.55 (mg/100g) in tied, sealed and vacuum sealed packs, respectively which further increased to 7.10, 7.18 and 7.20 (mg/100g) after 120 days of storage and then finally reached to 7.86, 7.83 and 7.65 (mg/100 g) after storage of 180 days at room temperature.

A similar type of study was carried out by Abiodun et al (2007). They assessed the comparative changes in the physical and chemical components of five different species of smoked freshwater fish: Bony tongue (*Heterotisniloticus*), African carp (*Labeocoubie*), Snake fish (*Parachannaobscura*), Nile Tilapia (*Oreochromisniloticus*) and African mud catfish (*Clariasgariepinus*) during storage. The fish were left in the plastic baskets for 56 days at ambient temperature (25-32°C).Biochemical indexes carried out were: Total Volatile Nitrogen (TVN), pH, Peroxide Value (PV) and Free Fatty Acid (FFA) levels. The pH values decreased over the weeks and all the species became more acidic. Eyo (1993) stated that pH is an indicator of the extent of microbial spoilage in fish and that some proteolytic microbes produce acid after decomposition of carbohydrate, thereby increasing the acid level of the medium. The pH value is a reliable indicator of the degree of freshness or spoilage. Decrease in the pH level is due to the fact that carbohydrate of the fish was fermented to acids.

Changes in microbial load

APC (Aerobic Plate Count) value

The total bacterial load expressed as colony forming unit in one gram sample (CFU/g) of the representative samples. After preparing salt-smoke-dried tengra the APC was observed 1.13×10^4. With the progress of storage time at room temperature the bacterial load increased in all three samples packed in tied, sealed and vacuum sealed packs. The values of APC increased to 2.32×10^4, 2.72×10^4 and 2.69×10^4 CFU/g in tied, sealed and vacuum sealed packs after 30 days of storage which further increased to 6.60×10^4, 5.88×10^4 and 7.40×10^4 after 90 days of storage. Finally on 180th day of storage APC value increased to 6.82×10^5, 5.27×10^5 and 4.42×10^5.

The obtained APC values in the present study are quite similar to the APC values reported by Rana *et al*. (2019) who carried out an investigation on the changes in microbiological components of Salt-smoke-dried (SSD) products prepared from two different SIS such as tengra (*Mystus tengara*) and batashi (*Neotropius atherinoides*) during storage at ambient (26-28°C) and refrigeration (4°C) temperature along with other parameters. Bacterial load in fresh tengra and batashi was found 3.84×10^5 and 2.72×10^5 CFU/g, respectively whereas, after smoking bacterial load reduced to 4.62×10^4 and 2.64×10^4 CFU/g, respectively. The initial bacterial load was 1.02×10^4 and 1.8×10^4 CFU/g for salt-smoke-dried and control dried tengra respectively and 1.14×10^4 and 1.88×10^4 CFU/g for salt-smoke-dried and control dried batashi, respectively. The bacterial load increased slowly with the progress of storage time and the value of Standard Plate Count (SPC) at the 60 day for the products stored at ambient temperature were increased to 3.32×10^4 and 1.74×10^5 CFU/g for salt-smoke-dried and control dried tengra, respectively and 4.2×10^4 and 2.5×10^5 for salt-smoke-dried and control dried batashi, respectively. Similar findings has also been observed by Larmond (1977) bacterial count of commercially dried freshwater fish samples ranged from 1.84×10^4 to 5.3×10^6 CFU/g. In another study for dried small fishes Hasan *et al.* (2006) showed that, the bacterial load of traditional, rotary and solar tunnel dried products (mola, tengra and katcki), were in the range of 1.43×10^8 to 2.89×10^8 CFU/g, 1.91×10^8 to 2.84×10^8 CFU/g and 1.95×10^8 to 2.59×10^8 CFU/g respectively which are in agreement with the present study.

Table 4. Changes in Aerobic Plate Count (CFU/g) of salt-driedtengra (*Mystustengara)* in different packs stored at room temperature (26 to 28˚C)

Days	Tied Pack (CFU/g)	Sealed Pack (CFU/g)	Vacuum Sealed Pack (CFU/g)
0	1.13×10^4	1.13×10^4	1.13×10^4
30	2.32×10^4	$2.72\text{x } 10^4$	$2.69\text{x } 10^4$
60	$5.11\text{x } 10^4$	4.30×10^4	$5.41\text{x } 10^4$
90	$6.60\text{ x}10^4$	$5.88\text{x}10^4$	7.40×10^4
120	$3.80\text{ x}10^5$	1.20×10^5	$8.65\text{x } 10^4$
150	4.61×10^5	$3.68\text{ x}10^5$	$2.85\text{x } 10^5$
180	$6.82\text{x } 10^5$	$5.27\text{x}10^5$	4.42×10^5

Conclusion

The obtained values for nutritional, biochemical and microbiological parameters showed that salt-smoke-dried tengra prepared in the laboratory can be stored at room temperature for about 6 months and among

different packs vacuum sealed pack performed best from the view point of keeping quality.

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