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Article

Nutritional and microbiological quality assessment of salt-smoke-dried product prepared from tengra (*Mystus tengara*) kept at ambient (26-28°C) and refrigeration temperature (4°C)

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Abstract: Study was conducted to identify the changes in nutritional and microbiological aspects of fresh, smoked, salt-smoke-dried (SSD: treated with salt, smoke and sunlight), Control dried (CD: treated only with sunlight) tengra (*Mystus tengara*) during storage at ambient temperature (26-28^{o}C) and refrigeration temperature (4^{0}C). The study was done to investigate the effect of natural preservatives salt and smoke on the shelf life of the product over the storage period. 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. The initial TVB-N and SPC value for SSD tengra was 5.86 mg/100g and 1.02×10^4 CFU/g respectively. During storage period the TVB-N and SPC value slowly increased and the values reached to 18.21 mg/100g and 3.32×10^4 CFU/g respectively for salt-smoke-dried tengra stored at ambient condition whereas 11.81mg/100g and 2.14×10^4 CFU/g respectively for the products stored at refrigeration temperature. The overall quality of salt-smoke-dried product was better than control dried product on the basis of organoleptic, nutritional and microbial aspects. Information obtained from this study it is cleared that, combination of salting, smoking and drying is efficient method of fish processing which could be useful to consumers, processors, and nutritionist at national and global basis.

Keywords: tengra; salt-smoke-dried; nutritional quality; microbiological quality

1. Introduction

Spoilage in fish ultimately results in the organoleptic, chemical and biochemical change in fish. These changes can be reduced by using proper preservation method. From the age old system curing of fish is being used as means of preservation for increasing its shelf life and its various use by the consumers at different levels. Curing generally include the methods like, salting, smoking and drying fish are in principle the reduction of moisture to decrease the water activity (a_W) in fish muscle. Proper handling, processing and preservation during post-harvest period are a prerequisite for minimizing the spoilage loss (Clucas, 1981). Among them Smoking is one of the traditional fish curing methods aimed at processing and reducing post-harvest losses. Smoking enhances flavor and increase utilization of the fish (Nahid *et al.*, 2016). However, in Bangladesh, generally all these curing methods for fish processing mentioned above are well accepted and more or less popular as separate by the consumers at different levels and even two methods altogether for one product is being popular as in case of products from hot smoking (where brining and smoking is done together) and salt drying (where salting and drying is done together) (Mansur *et al.*, 1998). It is assumed that the above

mentioned three curing process viz. salting, smoking and drying in combination would produce a new, better quality product probably with a longer shelf-life by significantly reducing water activity in the flesh of fish. This type of product would be much preferred by consumers because of its texture, taste and flavor. In our country salt-smoke-dried fish product is recent addition to the fishery products and preservation of Small Indigenous Species (SIS) fish is a new trend or new kind of research activities in this country. Due to high palatable, taste and rich in nutrients two commercially important variety of Bangladeshi freshwater SIS of fish such as tengra (*Mystus tengara*) have been selected for the present research work. A salt-smoke-dried fish product thus may serve as one of the better-accepted quality fishery products showing a longer shelf life of even more than one year at ambient temperature in a proper packaged container and more than one year which are stored at refrigeration condition. 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). Therefore, considering the possible health risk and the nutritional benefits associated with fish consumption; this study was carried out to complement efforts aimed at ascertaining the effect of smoke-drying on the nutritive value and shelf life of the common (SIS) fish (tengra) which is available and consumed in Bangladesh.

2. Materials and Methods

2.1. Sample Collection

For the preparation of salt-smoke-dried products freshwater fish species, tengra (*Mystus tengara*) was collected as fresh from the Machua bazar, Mymensingh town by direct contract with supplier in the early morning. The collected fresh fish samples were carried in ice stored condition to the laboratory of Fisheries Technology, Bangladesh Agricultural University.

2.2. Washing and Dressing of Fish

At first the fishes were washed in potable water, weighed the whole fish on a sensitive balance then dressed and weighed the dressed fish in the laboratory.

2.3. Brining, Dewatering and air drying

After draining out water from washed raw materials, the fishes were prepared for salt treatment. The fishes were immersed into a plastic bucket containing 25% salt solution for 5 min ensuring all fishes as completely immersed into salt solution. After brining the fishes were taken out of the salt solution and kept them on a plastic tray for drying at room temperature for about 10 minutes. After air drying the fishes were placed inside the smoking kiln with the help of removable wire mesh tray.

2.4. Smoking

The lower chamber of the smoking kiln had the facilities of burning saw dust or wood chips on an iron bowl so as to produce a continuous and a homogenous hot smoke. During the smoking procedure, the smoke temperature inside the smoking kiln was recorded by a sensitive thermometer. The desired temperature ranged between 50-55^{0}C and was maintained manually by controlling the outlet of the smoking chamber. During the smoking operation fishes were turned upside down in the mid period, by using a corrosion free metal tong to make the salt-smoked sample smooth and steady in texture and appearance. After smoking, salt-smoked products (Figure 1) were cooled for 15-20 minutes at room temperature which facilitated to prevent breaking of smoked fish.

2.5. Drying Procedure

Samples were dried with the help of a Ring tunnel dryer. A 6.5 to 7 feet long piece of bamboo was splitted in to 6-7 parts of equal size, having the rear end unsplitted. Several rings (outer rings) were made of split bamboo are by tying up with individual splitted bamboo. Round thin-meshed sieves (*chaluni*) made of bamboo inside the shreds were set and tied at regular distance to give a shape of a robust torpedo. The vertical distance between two sieves was about 1.7 feet. The ring tunnel loaded with salt-smoked fish, same amount of fishes were spreaded on each of the sieves for effective drying. All sides of the tunnel was carefully covered by the polythene except a little hole was kept open at the top of the ring tunnel for exit of hot air and moisture. Temperature inside and outside the ring tunnels during the whole day of drying period of tengra fishes was recorded carefully with the help of a thermometer. The process continued till the completion of drying. For complete drying of tengra took about 18-20 hours so that the final products had moisture level of less than 16-20%.

Figure 1. Salt-smoked tengra fish.

Figure 2. Salt-smoke-dried tengra fish.

2.6. Packaging, Leveling and Storage of the salt-smoke-dried fish products

The Salt-smoke-dried fishes (Figure 2) were packed in polythene bag followed by sealing using an electrical sealing machine (PFS-300) to prevent moisture absorption. Each bag contained about 100g salt-smoke-dried fishes with proper labeling. The packaged fishes were divided into two parts for storage-one part was kept at refrigeration temperature (4^0C) and other portion kept in ambient temperature (26-28^0C).

2.7. Analysis

At first the collected fresh fish, smoked fish as well as salt-smoke-dried fish samples were minced and homogenized separately in a grinder for the analysis. For quality and shelf life study sample was analyzed every 15 days interval for both the sample kept at ambient and refrigeration temperature. For analysis of nutritive quality proximate analysis was done by AOAC (1990) method. Total volatile Base Nitrogen (TVBN) and microbiological analysis was done by following standard methods.

3. Results and Discussion

Results obtained from the present study includes the results from biochemical composition includes proximate composition (moisture, protein, fat, ash and TVB-N value).

3.1. Changes in proximate composition

At the time of salt-smoke-drying the percentage of moisture content decreased from their original values and protein, lipid and ash content were increased due to the loss of water from the fish body. This observation is in agreement with the findings of smoke-dried chapila and guchi baim (Nahid *et al*., 2014). Similarly, Smoke-drying procedures increased the protein, lipid and ash contents of Kakila and Baim (Nahid *et al.*, 2016).

Table 1. Nutritional and Biochemical composition of fresh, salt-smoked, salt-smoke-dried and control dried tengra fish stored at ambient temperature (26-28)^{0}C.

Day of Observation	Products Name	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/ gm.)
0	Fresh fish	76.06±0.28	56.18±0.54	31.16±0.33	11.69±0.58	1.94±0.42	3.84×10^5
0	Salt-smoked fish	61.09±0.14	56.80±0.21	31.30±0.57	11.92±0.15	4.69±0.22	4.62×10^4
0	SSD	18.80±0.14	63.40±0.07	19.95±0.14	16.55±0.07	5.86±0.12	1.02×10^4
0	CD	18.36±0.25	62.52±0.13	20.48±0.38	15.99±0.34	6.88±0.05	1.8×10^4
15	SSD	19.0±0.11	63.31±0.12	19.80±0.17	16.32±0.07	8.74±0.63	1.26×10^4
15	CD	18.64±0.28	62.41±0.50	20.22±0.27	15.76±0.39	13.52±0.22	2.78×10^4
30	SSD	19.4±0.03	63.15±0.04	19.75±0.07	16.23±0.04	11.73±0.46	1.78×10^4
30	CD	19.50±0.48	62.19±0.41	20.12±0.55	15.60±0.10	17.24±0.61	3.6×10^4
45	SSD	21.02±0.37	63.05±0.27	19.25±0.14	16.03±0.25	15.34±0.60	2.62×10^4
45	CD	20.06±0.14	61.97±0.33	19.91±0.54	15.44±0.40	19.64±0.46	4.4×10^4
60	SSD	23.43±0.10	62.75±0.21	19.07±0.30	15.99±0.10	18.21±0.87	3.32×10^4
60	CD	25.86±0.16	61.10±0.39	18.88±0.73	15.11±0.46	21.20±0.21	1.75×10^5

##SSD=Salt-smoke-dried, CD=Control dried product (Values are shown on dry matter basis).

Table 2. Nutritional and Biochemical composition of salt-smoke-dried and control dried tengra fish stored at refrigeration temperature (4)^{0}C.

Day of Observation	Products Name	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/ gm.)
0	Fresh fish	76.06±0.28	56.18±0.54	31.16±0.33	11.69±0.58	1.94±0.42	3.84×10^5
0	Salt-smoked fish	61.09±0.14	56.80±0.21	31.30±0.57	11.92±0.15	4.69±0.22	4.62×10^4
0	SSD	18.80±0.14	63.40±0.07	19.95±0.14	16.55±0.07	5.86±0.12	1.02×10^4
0	CD	18.36±0.25	62.52±0.13	20.48±0.38	15.99±0.34	6.88±0.05	1.8×10^4
15	SSD	18.90±0.25	63.28±0.21	19.90±0.38	16.42±0.17	6.24±0.11	1.2×10^4
15	CD	19.64±0.22	62.32±0.40	19.71±0.30	15.85±0.14	7.24±0.18	1.94×10^4
30	SSD	19.10±0.14	63.16±0.16	19.80±0.35	16.24±0.17	7.16±0.23	1.34×10^4
30	CD	20.78±0.46	62.03±0.27	18.68±0.19	15.22±0.20	9.34±0.26	2.48×10^4
45	SSD	19.82±0.14	62.86±0.37	19.71±0.26	16.19±0.17	8.96±0.41	1.66×10^4
45	CD	21.48±0.27	61.57±0.45	18.42±0.47	15.11±0.32	11.45±0.14	4.5×10^4
60	SSD	21.20±0.35	62.54±0.08	19.54±0.18	16.12±0.47	11.81±0.69	2.14×10^4
60	CD	22.10±0.61	60.90±0.30	17.66±0.15	14.79±0.37	15.08±0.24	1.08×10^5

##SSD=Salt-smoke-dried, CD=Control dried product (Values are shown on dry matter basis).

The moisture content can be used as one of indicators to the rate at which deterioration occurred in the products resulting in the early decomposition. In the present study, the moisture content of salt-smoke-dried and control dried tengra fish rose from 18.80 to 23.43% (60 days); from 18.36 to 25.86% (60 days) and from 18.80 to 21.20% (60 days); from 18.36 to 22.10% (60 days) respectively for the product stored at room temperature and refrigeration temperature (Table 1& Table 2). Moisture content increased in these types of products due to the absorption of moisture from surrounding since there was no re-drying during storage period (Darmola *et al.* 2007). The moisture content of smoke-dried chapila, kakila and baim fish rose 12.36 to 14.05%, 11.69 to 13.93% and 8.22 to 15.37% respectively during storage at room temperature which is more or less similar with the present study (Nahid *et al*., 2016).

Fish protein is of high quality and contains sufficient amounts of all the essential amino acids required by the body for growth, maintenance of lean muscle tissue and active metabolism (Talabi, 1995). In this experiment, protein content increased in salt-smoke-dried product prepared from tengra fish, when compared with fresh fish, it was suggested that the protein nitrogen was not lost during smoke-drying methods (Puwastien *et al*., 1999). It was found in the Present study that in fresh processed condition protein content of salt-smoke-dried (SSD) and control dried (CD) tengra was 63.40 and 62.52%, respectively on dry matter basis. The protein content of salt-smoke-dried (SSD) and control dried (CD) tengra decreased to 62.75 and 61.10%, respectively on dry matter basis after two month storage at ambient temperature (Table 1 & Table 2). After two month stored at refrigeration temperature the protein content of salt-smoke-dried control dried tengra showed a small decrease to 62.54 and 60.90% on dry matter basis, respectively (Table 2). In storage condition, the protein content decreased significantly with the time due to water soluble protein diffused out to the surrounding for exosmosis (Hasan *et al.*, 2013). Darmola *et al.* (2013) found the decreasing trend of protein content in hot smoked *C. gariepinus* during storage period which is more or less similar with the present findings. Also, Nahid *et al.*, 2016 observed the decreasing trend of protein content in smoke-dried chapila, kakila and baim during storage period which is in line with the present research findings.

The initial lipid content of salt-smoke-dried tengra was high compared to the fresh fish. Lipid content of salt-smoke-dried (SSD) and control dried (CD) tengra was 19.95 and 20.48%, respectively on dry matter basis, immediately after preparation. However during the study period (60 days) lipid content of the samples slowly decreased from their initial values, this was due to the inverse relationship between moisture and fat content. After two month storage at ambient temperature lipid content of salt-smoke-dried and control dried tengra was decreased from 19.95 to 19.07 and from 20.48 to 18.88%, respectively on dry matter basis (Table 1). On the other hand, products stored at refrigeration temperature lipid content of salt-smoke-dried and control dried tengra was found to be decreased from 19.95 to 19.54 and from 20.48 to 17.66%, respectively on dry matter basis (Table 2). Similar decreasing trend of lipid content was found in salt and garlic treated smoke-dried chapila and guchi baim (Nahid *et al.*, 2014).

Ash content of salt-smoke-dried and control dried fish samples was higher than that of fresh fish. Salan *et al.*, 2006 observed increase of ash content in smoked *C. gariepinus* due to the loss of humidity and the significant reduction of moisture content during smoking and drying. Ash content of the products slowly decreased with the

extension of storage period. After two month storage at ambient temperature ash content of salt-smoke-dried and control dried tengra was found to decrease to 15.99 and 15.11% respectively. On the other hand, samples kept 60 days at refrigeration temperature, ash content of salt-smoke-dried (SSD) and control dried (CD) tengra was decreased to 16.12 and 14.79%, respectively. The ash content changes with the time of storage due to absorbance of moisture and loss of protein (Hasan *et al.*, 2013). Nahid *et al*., 2014 found that the ash content of salt and garlic treated chapila and guchi baim was decreased during the storage period which is similar with the present study.

3.2. TVB-N (mg/100g) value

In this study the higher value of TVB-N were reported in fresh salt-smoke-dried, control dried tengra compared with fresh fish (Figure 3). TVB-N content of salt-smoke-dried and control dried tengra was 5.86 and 6.88 mg/100g, respectively in fresh processed condition. It was found a continuous increase of TVB-N value of smoke-dried products throughout the storage period which could be due to gradual degradation of the initial protein to more volatile product such as total base nitrogen (Darmola *et al.*, 2007). The TVB-N value for the products stored at ambient temperature was varied between 5.86 (1st day) to 18.21 mg/100g (60 day) for salt-smoke-dried tengra, 6.88 (1st day) to 21.20 mg/100g (60 day) for control dried tengra. On the other hand products stored at refrigeration temperature the TVB-N values were found varied between 6.88 (1st day) to 15.08 mg/100g (60 day) for control dried tengra, 5.86 (1st day) to 11.81 mg/100g (60 day) for salt-smoke-dried tengra (Figuire 3). Increase in final values of TVB-N in this study was similar to the result of Hasan *et al.* (2006) who reported that the TVB-N values of the dried products from rotary dryer ranged from 10.64 mg/100g to 17.52 mg/100g with lowest in mola dried in rotary dryer in room condition and highest in tengra dried in rotary dryer under direct sunlight. Pearson (1982) recommended that 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. Increase in final values of TVB-N in this present research work is similar with the other researcher (Abolagba, 2008 and Trinidad, 1986).

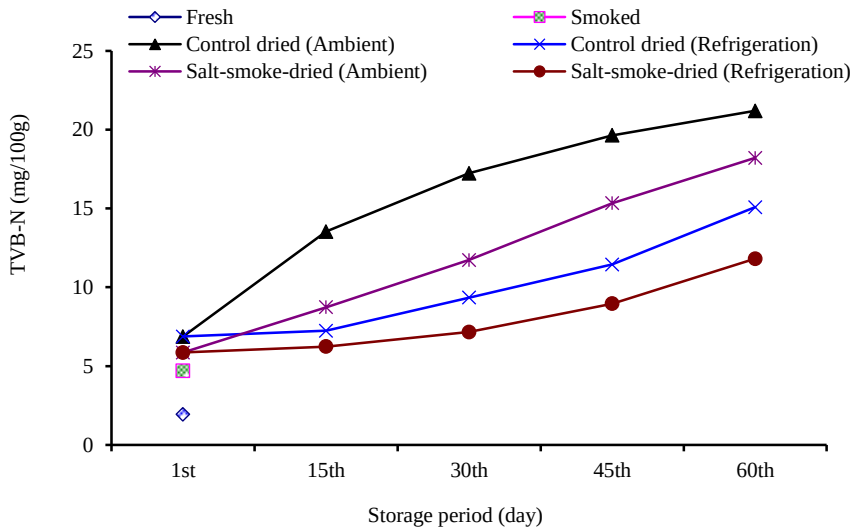

Figure 3. Changing pattern of TVB-N content (mg/100g) of tengra with different treatments stored at ambient (26-28°C) and refrigeration (4°C) temperature.

3.3. Microbiological Quality

Bacterial load in fresh tengra was found 3.84×10^5 CFU/g, after smoking bacterial load reduced to 4.62×10^4 CFU/g (Figure 4). This is due to the bacteriostatic and bactericidal effect of wood smoke, heat generation from smoke and also reduction of moisture content in fish body. 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. The bacterial load increased slowly with the progress of storage time and the value of Standard Plate Count (SPC) at the 60 day was $3.32x10^4$ and 1.74×10^5CFU/g for salt-smoke-dried and control dried tengra, respectively. On the other hand value of SPC for the products stored at refrigeration temperature was found changed to 2.14×10^4 and 1.08×10^5 CFU/g for salt-smoke-dried and control dried tengra, respectively (Figure 4). As the duration of storage increased the processed fish might have absorbed small amounts of moisture from surrounding atmosphere providing enabling environment for microbial growth (Eyo, 2006). Total viable counts (TVC) of smoke-dried fish samples were increased with increase in duration of

storage due to growth and multiplication of the microbes (Bilgin *et al.*, 2008). Zaki *et al.* (1976) that reported the total bacterial count decreased after drying, owing to the high salt content and the presence of reduced free water in fish tissues and Coliforms were not present after drying.

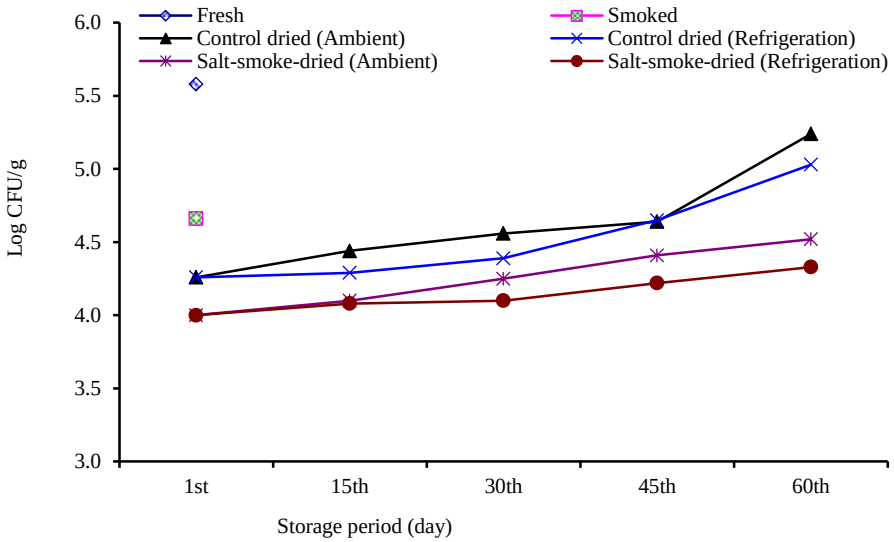

Figure 4. Changing pattern of bacterial load (log CFU/g) of tengra with different treatments stored at ambient (26-28°C) and refrigeration (4°C) temperature.

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 x 10^8 to 2.89 × $l0^8$ CFU/g, 1.9l × $l0^8$ to 2.84×$l0^8$ CFU/g and l.95×$l0^8$ to 2.59×10^8 CFU/g, respectively. The present experiment with tengra also provides more or less similar result with the findings of the above studies.

4. Conclusions

The present study showed the basic nutritional information on freshwater small fish; tengra, it also provides a possible application of salt-smoke-drying as an efficient drying for fish preservation especially in developing countries like Bangladesh where all the required sophisticated storage equipment is not available. The biochemical and microbiological analysis proved that the overall quality of salt-smoke-dried tengra was best after two month storage at ambient and refrigeration temperature even in normal packaged condition. Salt-smoke-dried SIS (tengra) produced in smoking kiln followed by drying in ring tunnel dryer can be stored in polythene package at ambient and refrigeration temperature for more than two months without any quality loss, however the salt-smoke-dried SIS products stored in refrigeration temperature can provide much longer shelf-life by minimizing the moisture uptake and bacterial load. It was observed that the use of salt and smoke comparatively had a special smoky flavor with good texture in the product. The product made by this process in ring tunnel showed a better hygienic aspect by shortening the drying period of fish.

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Conflict of interest

None to declare.

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