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Study on acceptability and shelf life of salt-smoke-dried products prepared from two different species of sis kept at different storage condition

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Abstract
An investigation was conducted to determine 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 (*Mystus tengara*) and batashi (*Neotropius atherinoides*) during storage at ambient (26-28ºC) and refrigeration (4ºC) 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 percentage of moisture increased whereas protein, fat, and ash content considerably decreased. After two month storage at ambient temperature the protein, lipid and ash content for SSD tengra and batashi were 62.75, 19.07 and 15.99%; and 65.0, 15.9 and 15.95%, respectively whereas the values of the same parameters stored at refrigeration temperature were 62.54, 19.54 and 16.12%; 65.03, 16.16 and 16.12%, respectively on dry matter basis. The TVB-N and SPC value reached to 18.21 mg/100g and 3.32×10^4 CFU /g; 17.94 mg/100g and 4.2×10^4 CFU/g, respectively for SSD tengra and batashi, stored at ambient condition which was found decreased for the products stored at refrigeration temperature. From the overall performance, the products kept at refrigeration temperature showed better perfectness and shelf life than the products stored at ambient temperature.

Keywords: Salt-smoke-dried, Proximate composition, Acceptability, Shelf-life, Microbiological

1. Introduction
Fish occupies the foremost places among the food products of animal origin (meat, poultry, milk, eggs etc.) in nutritive value because of the presence of valuable proteins, lipids, vitamins and various kinds of mineral substances. Spoilage of fish begins as soon after the fish dies. Spoilage is the result of a series of complicated changes brought about in the dead fish mainly by enzymes and bacteria. These changes ultimately result in the organoleptic, chemical and biochemical change in fish. These changes can be reduced by using proper preservation method. 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. During post-harvest period large amount of fish are spoiled and wasted due to lack of proper measure for processing and preservation because of the fact that neither we can consume all the fishes caught nor can we transport to other places wherever necessary due to our insufficient handling and transportation system. Smoking enhances flavor and increase utilization of the fish [13]. The quality of fish processed by the various methods cannot be the same and hence its subsequent effect on the fish's shelf life also varies. Of all food preservation methods, drying has received the most widespread and enthusiastic publicity in recent years [3]. Smoking is a method of preserving fish which involves drying, cooking and depositing natural wood-smoke chemicals like tars, phenols and aldehydes all of which have powerful bactericidal action and prevent the growth of other microorganisms on the flesh of the fish [9]. Smoking demonstrated a better efficient method of fish processing in terms of the retention of protein value and reduction in the moisture content [14]. Smoking also works against infestation. There are two major important methods of smoking fish - cold and hot, which give different products. The most typical feature of smoke-dried products is flavor and it is generally considered that phenol compounds and other components soluble in water are the most important criteria in creating flavor in smoked products.

In Bangladesh, smoked fish 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*) and batashi (*Neotropius atherinoides*) have been selected to achieve the following objectives such as to evaluate the quality and shelf life of Salt-smoke-dried products stored at ambient (26-28^{0}C) and refrigeration temperature (40^{0}C) as well as to analyze the microbial changes of salt-smoke-dried and traditional dried products in the laboratory.

2. Materials and Methods

2.1 Sample Collection

For the preparation of salt-smoke-dried products freshwater fish species, tengra (*Mystustengara*) and batashi (*Neotropius atherinoides)* 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 Fish Salt-smoke-drying

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. 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, after smoking, products were cooled for 15-20 minutes at room temperature which facilitated to prevent breaking of smoked fish. Samples were dried with the help of a Ring tunnel dryer. 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. The smoke-dried fishes were packed in polythene bag followed by sealing using an electrical sealing machine (PFS-300) to prevent moisture absorption. The packaged fishes were divided into two parts for storage-one part was kept at refrigeration temperature (4^{0}C) and other portion kept in ambient temperature (26-28^{0}C).

2.4 Analysis

For quality and shelf life study sample was analyzed every 15 days interval for both the sample kept at ambient and refrigeration temperature. The sensory parameters such as color, odor, texture, insect infestation, presence of broken pieces and overall quality of salt-smoke-dried, control dried (treated without salt and smoke) and traditionally dried products prepared from tengra and batashi stored at ambient and refrigeration temperature were examined on nine point scale [11] considering 9.0 as best and 1.0 as worst. Parameters on the questionnaire were as follows Like extremely=9, Like very much=8, Like moderately=7, Like slightly=6, Neither like nor dislike=5, Dislike lightly=4, Dislike moderately=3, Dislike very much=2 and Dislike extremely=1. For analysis of nutritive quality proximate analysis was done by [1] method. Total volatile Base Nitrogen (TVBN) and microbiological analysis was done by following standard methods. Moisture absorbed by dried fish immersed in water at a certain temperature and time is called water reconstitution or rehydration. It is one of the most important physical parameter to assess the quality of the dried and smoke dried products and expressed as percent water reconstitution under the defined condition. The percent gain or uptake of moisture by the fish flesh was marked as percent water reconstitution or rehydration (%) and calculated by using the following formula:

$$Water\ Reconstitution\ (\%) = \frac{Wr - Wi}{Wi} \times 100$$

W_i = Initial weight of the dry fish
Wr = Weight of the dry fish after water absorption

3. Results

3.1 Sensory Score value

The mean general acceptability score after two month storage in ambient condition was in the range of 5.90 to 6.09 with minimum value obtained from control dried batashi and maximum value was found in salt-smoke-dried tengra (Figure 1).

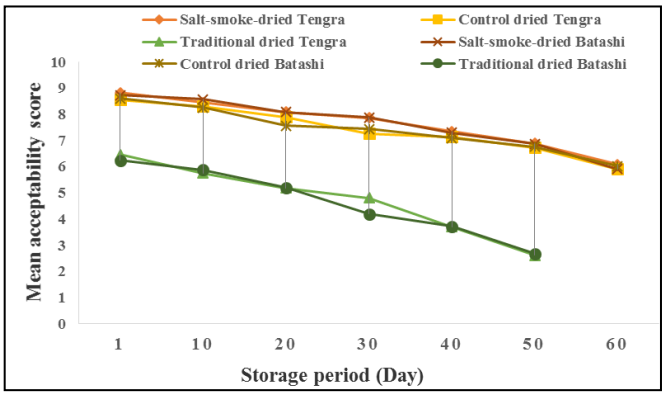

Fig 1: Changes in sensory scores of tengra and batashi with different treatments

3.2 Changes in proximate composition

The moisture content of fresh tengra and batashi was 76.06 and 75.81%, respectively. After 50 minutes of smoking moisture content was found to be decreased to 61.09 and 61.65%, respectively. Moisture content of the products stored at ambient temperature (26-28^{0}C) varied between 18.80 (0 day) to 23.43% (60 day) and 18.10 (0 day) to 23.26% (60 day) for salt-smoke-dried tengra and batashi, respectively whereas 18.36 (0 day) to 25.86% (60 day) and 18.54(0 day) to 26.30% (60 day) for control dried tengra and batashi, respectively (Table 1). On the other hand, samples kept at refrigeration temperature (4^{0}C) moisture content of salt-smoke-dried tengra and batashi was increased to 21.20 and 21.42% for tengra and batashi, respectively whereas in control dried samples increased to 22.10 and 22.86% for tengra and

batashi, respectively (Table 2).

The protein content in fresh tengra and batashi was 56.18 and 64.65%, respectively and 56.80 and 65.95% in smoked products, respectively on dry matter basis. Present study found that in fresh processed condition protein content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was 63.40, 65.93 and 62.52, 65.50%, respectively on dry matter basis. The protein content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi were decreased to 62.75, 65.0 and 61.10, 58.96%, respectively on dry matter basis after two month storage in ambient temperature (Table 1). After two month stored at refrigeration temperature the protein content of salt-smoke-dried control dried tengra and batashi showed a small decrease to 62.54, 65.03 and 60.90, 62.80% (on dry matter basis), respectively (Table 2).

Table 1: Proximate composition, TVBN and SPC value for salt-smoke-dried (SSD) and control dried tengra and batashi stored at ambient temperature (26-28) ^{0}C

Day	Products Name		Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/g.)
0	Fresh fish	Tengra	76.06±0.28	13.45±0.13(56.18±0.54)	7.46±0.08(31.16±0.33)	2.80±0.14(11.69±0.58)	1.94±0.42	3.84×10^5
		Batashi	75.81±0.18	15.64±0.17(64.65±0.70)	3.80±0.07(15.71±0.29)	3.20±0.14(13.23±0.57)	1.80±0.32	2.72×10^5
	Salt-smoked fish	Tengra	61.09±0.14	22.10±0.08(56.80±0.21)	12.18±0.22(31.30±0.57)	4.64±0.06(11.92±0.15)	4.69±0.22	4.62×10^4
		Batashi	61.65±0.13	25.29±0.11(65.95±0.29)	6.46±0.11(16.84±0.29)	4.82±0.06(12.57±0.16)	4.25±0.26	2.64×10^4
	SSD	Tengra	18.80±0.14	51.48±0.06(63.40±0.07)	16.2±0.11(19.95±0.14)	13.44±0.06(16.55±0.07)	5.86±0.22	1.02×10^4
		Batashi	18.10±0.11	54.00±0.14(65.93±0.17)	14.0±0.14(17.09±0.17)	13.84±0.05(16.90±0.06)	6.14±0.18	1.14×10^4
	CD	Tengra	18.36±0.25	51.04±0.11(62.52±0.13)	16.72±0.31(20.48±0.38)	13.06±0.28(15.99±0.34)	6.88±0.05	1.8×10^4
		Batashi	18.54±0.18	53.36±0.17(65.50±0.21)	14.68±0.14(18.02±0.17	13.25±0.41(16.27±0.50)	7.05±0.46	1.88×10^4
15	SSD	Tengra	19.0±0.11	51.28±0.10(63.31±0.12)	16.04±0.14(19.8±0.17)	13.22±0.06(16.32±0.07)	8.74±0.63	1.26×10^4
		Batashi	18.86±0.17	53.18±0.06(65.54±0.07)	13.72±0.20(16.91±0.25)	13.54±0.13(16.69±0.16)	8.82±0.38	1.8×10^4
	CD	Tengra	18.64±0.28	50.78±0.41(62.41±0.50)	16.45±0.22(20.22±0.27)	12.82±0.32(15.76±0.39)	13.54±0.22	2.78×10^4
		Batashi	18.78±0.30	52.86±0.11(65.08±0.14)	14.52±0.36(17.88±0.44)	12.70±0.28(15.63±0.34)	9.46±0.46	2.64×10^4
30	SSD	Tengra	19.4±0.03	50.90±0.03(63.15±0.04)	15.92±0.06(19.75±0.07)	13.10±0.14(16.25±0.17)	11.73±0.46	1.26×10^4
		Batashi	20.14±0.06	52.26±0.03(65.44±0.04)	13.12±0.06(16.43±0.08)	12.96±0.03(16.23±0.04)	11.68±0.42	2.32×10^4
	CD	Tengra	19.50±0.48	50.06±0.33(62.19±0.41)	16.20±0.44(20.12±0.55)	12.56±0.08(15.60±0.10)	17.24±0.61	3.6×10^4
		Batashi	20.16±0.22	51.88±0.14(64.98±0.18)	13.94±0.4417.46±0.55)	12.14±0.09(15.21±0.11)	13.46±0.14	3.9×10^4
45	SSD	Tengra	21.02±0.37	49.80±0.21(63.05±0.27)	15.20±0.11(19.25±0.14)	12.66±0.20(16.03±0.25)	15.34±0.64	2.62×10^4
		Batashi	21.64±0.03	51.0±0.31(65.08±0.40)	12.68±0.20(16.18±0.26)	12.60±0.07(16.08±0.09)	15.76±0.54	2.9×10^4
	CD	Tengra	20.06±0.14	49.54±0.26(61.97±0.33)	15.92±0.43(19.91±0.54)	12.34±0.32(15.44±0.40)	19.64±0.46	4.4×10^4
		Batashi	21.10±0.09	50.78±0.33(64.36±0.42)	13.50±0.46(17.11±0.58)	11.86±0.24(15.03±0.30)	16.14±0.33	4.68×10^4
60	SSD	Tengra	23.43±0.10	48.05±0.16(62.75±0.21)	14.60±0.23(19.07±0.30)	12.24±0.08(15.99±0.10)	18.21±0.87	3.32×10^4
		Batashi	23.26±0.06	49.88±0.07(65.0±0.09)	12.20±0.25(15.9±0.33)	12.24±0.17(15.95±0.22)	17.94±0.21	4.2×10^4
	CD	Tengra	25.86±0.16	45.30±0.29(61.10±0.39)	14.0±0.54(18.88±0.73)	11.20±0.34(15.11±0.46)	21.20±0.21	1.74×10^5
		Batashi	26.30±0.34	43.45±0.62 (58.96±0.84)	11.80±0.06 (16.01±0.08)	10.68±0.29 (14.49±0.39)	17.94±0.23	2.5×10^5

The ash content of fresh tengra and batashi was 11.69 and 13.23%, respectively after smoking ash content was found increased to 11.92 and 12.57%, respectively on dry matter basis. At 0 day of observation ash content of salt-smoke-dried and control dried tengra and batashi had 16.55, 16.90 and 15.99, 16.27% (on dry matter basis), respectively. Ash content of all 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 and batashi was decreased to 15.99, 15.95 and 15.11, 14.49%, (on dry matter basis), respectively (Table 1), On the other hand, samples kept 60 days at refrigeration temperature, ash content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was decreased to 16.12, 16.12 and 14.79, 14.35%, (on dry matter basis), respectively (Table 2).

The lipid content of fresh tengra and batashi was found 31.16 and 15.71%, respectively after smoking lipid content increased to 31.30 and 16.84%, respectively on dry basis. Lipid content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was 19.95, 17.09 and 20.48, 18.02%, respectively on dry matter basis, just before storage. After two month storage at ambient temperature lipid content of salt-smoke-dried and control dried tengra and batashi was decreased to 19.07, 15.90 and 18.88, 16.01%, respectively (Table 1). On the other hand, products stored at refrigeration temperature lipid content of salt-smoke-dried and control dried tengra and batashi was found to be decreased to 19.54, 16.16 and 17.66, 16.77%, respectively (Table 2).

Table 2: Proximate composition, TVBN and SPC value for salt-smoke-dried (SSD) and control dried tengra and batashi stored at refrigeration temperature (4) ^{0}C

Day	Products Name		Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/g.)
0	Fresh fish	Tengra	76.06±0.28	13.45±0.13(56.18±0.54)	7.46±0.08(31.16±0.33)	2.80±0.14 (11.69±0.58)	1.94±0.42	3.84×10^5
		Batashi	75.81±0.18	15.64±0.17(64.65±0.70)	3.80±0.07(15.71±0.29)	3.20±0.14(13.23±0.57)	1.80±0.32	2.72×10^5
	Salt-smoked fish	Tengra	61.09±0.14	22.10±0.08(56.80±0.21)	12.18±0.22(31.30±0.57)	4.64±0.06(11.92±0.15)	4.69±0.22	4.62×10^4
		Batashi	61.65±0.13	25.29±0.11(65.95±0.29)	6.46±0.11(16.84±0.29)	4.82±0.06(12.57±0.16)	4.25±0.26	2.64×10^4
	SSD	Tengra	18.80±0.14	51.48±0.06(63.40±0.07)	16.2±0.11(19.95±0.14)	13.44±0.06(16.55±0.07)	5.86±0.22	1.02×10^4
		Batashi	18.10±0.11	54.00±0.14(65.93±0.17)	14.0±0.14(17.09±0.17)	13.84±0.0516.90±0.06)	6.14±0.18	1.14×10^4
	CD	Tengra	18.36±0.25	51.04±0.11(62.52±0.13)	16.72±0.31(20.48±0.38)	13.06±0.28(15.99±0.34)	6.88±0.05	1.8×10^4
		Batashi	18.54±0.18	53.36±0.17(65.50±0.21)	14.68±0.14(18.02±0.17	13.25±0.41(16.27±0.50)	7.05±0.46	1.88×10^4
15	SSD	Tengra	18.90±0.25	51.32±0.17(63.28±0.21)	16.14±0.31(19.90±0.38)	13.32±0.14(16.42±0.17)	6.24±0.11	1.2×10^4
		Batashi	18..32±0.14	53.76±0.11(65.82±0.13)	13.88±0.23(16.99±0.28)	13.68±0.07(16.75±0.09)	6.98±0.61	1.36×10^4

	CD	Tengra	19.64±0.22	50.08±0.32(62.32±0.40)	15.84±0.24(19.71±0.30)	12.74±0.11(15.85±0.14)	7.24±0.18	1.94×10^4
		Batashi	19.87±0.14	52.0±0.42(64.89±0.52)	14.28±0.21(17.82±0.26)	12.88±0.35(16.07±0.44)	7.24±0.36	1.96×10^4
30	SSD	Tengra	19.10±0.14	51.10±0.14(63.16±0.17)	16.02±0.28(19.80±0.35)	13.14±0.14(16.24±0.17)	7.16±0.23	1.34×10^4
		Batashi	19.20±0.21	53.04±0.16(65.64±0.20)	13.2±0.14(16.34±0.17)	13.14±0.19(16.21±0.24)	7.87±0.42	1.64×10^4
	CD	Tengra	20.78±0.46	49.14±0.21(62.03±0.27)	14.80±0.15(18.68±0.19)	12.06±0.16(15.22±0.20)	9.34±0.26	2.48×10^4
		Batashi	20.28±0.22	51.14±0.32(64.15±0.40)	13.98±0.24(17.53±0.30)	12.02±0.21(15.08±0.26)	8.36±.42	2.84×10^4
45	SSD	Tengra	19.82±0.14	50.40±0.31(62.86±0.37)	15.8±0.21(19.71±0.26)	12.98±0.14(16.19±0.17)	8.96±0.41	1.66×10^4
		Batashi	20.05±0.17	52.22±0.06(65.32±0.08)	13.00±0.28(16.24±0.35)	12.92±0.31(16.16±0.39)	9.63±0.69	2.2×10^4
	CD	Tengra	21.48±0.27	48.35±0.35(61.57±0.45)	14.46±0.37(18.42±0.47)	11.87±0.25(15.11±0.32)	11.45±0.14	4.5×10^4
		Batashi	21.86±0.48	49.82±0.38(63.75±0.49)	13.50±0.22(17.28±0.28)	11.64±0.46(14.89±0.59)	10.21±0.59	3.10×10^4
60	SSD	Tengra	21.20±0.35	49.28±0.06(62.54±0.08	15.40±0.14(19.54±0.18)	12.70±0.37(16.12±0.47)	11.81±0.69	2.14×10^4
		Batashi	21.42±0.25	51.10±0.13(65.03±0.17)	12.70±0.35(16.16±0.45)	12.67±0.07(16.12±0.09)	11.20±0.24	2.42×10^4
	CD	Tengra	22.10±0.61	47.44±0.23(60.90±0.30)	13.76±0.12(17.66±0.15)	11.52±0.29(14.79±0.37)	15.08±0.24	1.08×10^5
		Batashi	22.86±0.58	48.45±0.50(62.80±0.65)	12.94±0.34(16.77±0.44)	11.07±0.62(14.35±0.80)	12.84±0.38	1.16×10^5

(Values in parenthesis is shown on dry basis).

The ash content of fresh tengra and batashi was 11.69 and 13.23%, respectively after smoking ash content was found increased to 11.92 and 12.57%, respectively on dry matter basis. At 0 day of observation ash content of salt-smoke-dried and control dried tengra and batashi had 16.55, 16.90 and 15.99, 16.27% (on dry matter basis), respectively. Ash content of all 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 and batashi was decreased to 15.99, 15.95 and 15.11, 14.49%, (on dry matter basis), respectively (Table 1), On the other hand, samples kept 60 days at refrigeration temperature, ash content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was decreased to 16.12, 16.12 and 14.79, 14.35%, (on dry matter basis), respectively (Table 2).

The lipid content of fresh tengra and batashi was found 31.16 and 15.71%, respectively after smoking lipid content increased to 31.30 and 16.84%, respectively on dry basis. Lipid content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was 19.95, 17.09 and 20.48, 18.02%, respectively on dry matter basis, just before storage. After two month storage at ambient temperature lipid content of salt-smoke-dried and control dried tengra and batashi was decreased to 19.07, 15.90 and 18.88, 16.01%, respectively (Table 1). On the other hand, products stored at refrigeration temperature lipid content of salt-smoke-dried and control dried tengra and batashi was found to be decreased to 19.54, 16.16 and 17.66, 16.77%, respectively (Table 2).

3.3 Changes in TVB-N Values

The TVB-N value for the products stored at ambient temperature was 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 (Figure 2 & 3).

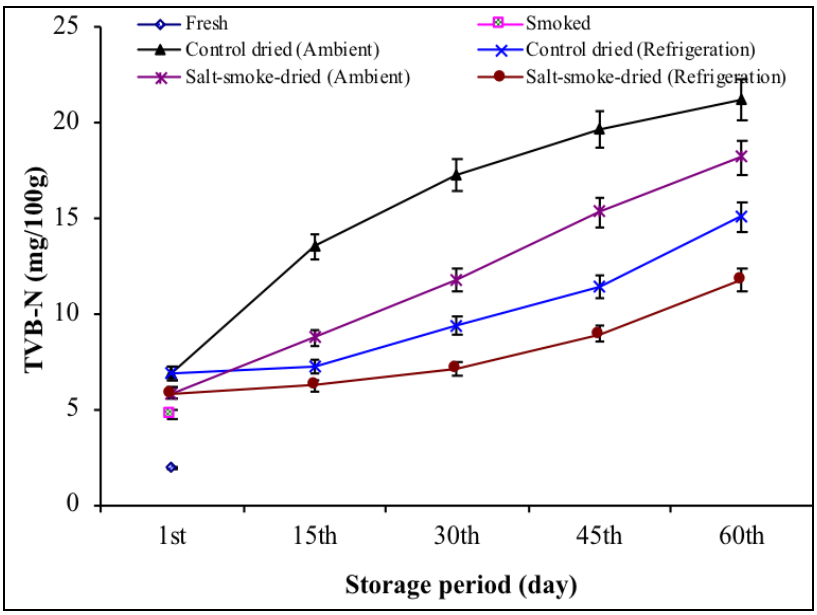

Fig 2: Changes in TVB-N (mg/100g) of tengra with different treatments stored at ambient and refrigeration temperature.

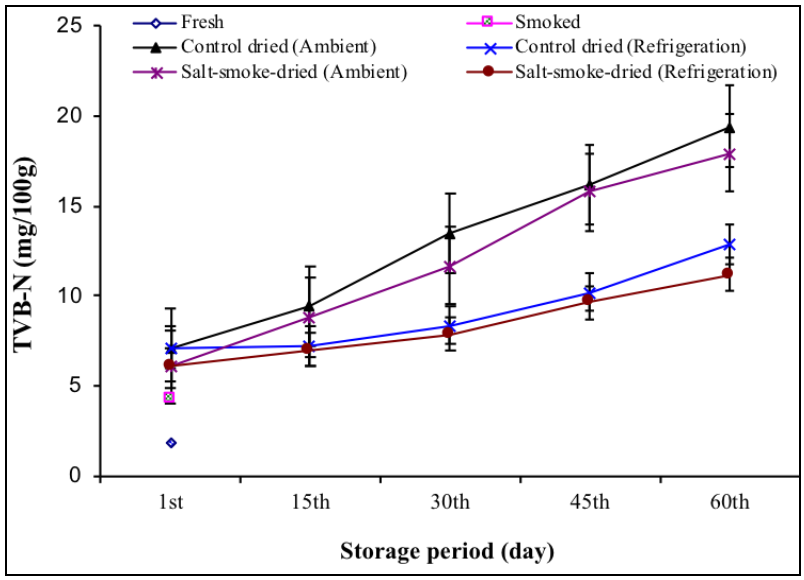

Fig 3: Changes in TVB-N (mg/100g) of batashi with different treatments stored at ambient and refrigeration temperature.

3.4 Microbial Analysis

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. On the other hand value of SPC for the products stored at refrigeration temperature were increased to $2.14\times\times10^4$ and 1.08×10^5 CFU/g for salt-smoke-dried and control dried tengra, respectively whereas 2.42×10^4 and 1.16×10^5 CFU/g for salt-smoke-dried and control dried batashi, respectively (Figure 4).

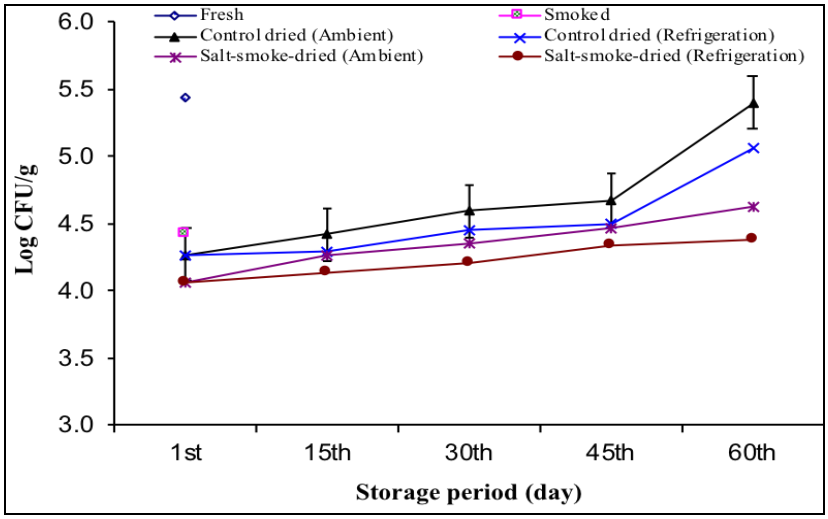

Fig 4: Changes in SPC (log CFU/g) of tengra with different treatments stored at ambient and refrigeration temperature.

4. Discussion

In the present study, the results of the sensory analysis indicated that the shelf-life of these salt-smoke-dried fishes was found better than the control dried products. After two month storage, salt-smoke-dried tengra and batashi stored at refrigeration and ambient temperature remained good condition. This agrees with the results of findings of storage of smoke-dried fish and crustacean's storage both at ambient temperature and chilling [5]. The quality of salt-smoke-dried products slightly decreased with the extension of storage period similar results were also noticed by [2] the quality of fish samples with respect to taste decreased as duration of storage increased. In another experiment [15] found that the highest mean general acceptability score was 8.87 and 8.85 for salt and garlic treated chapila and guchibaim, respectively. In proximate composition analysis, the moisture content was varied in ambient temperature whereas moisture content of salt-smoke-dried tengra and batashi was increased at refrigeration temperature. This increase may be attributed due to absorption of moisture from the surrounding since there was no re-drying during storage [5]. There was a gradual increase in moisture content of these three types of samples viz. SSD and CD tengra and batashi with increasing storage period similar results noticed by [15].

The protein content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi were decreased from 65 to 58.96% on dry matter basis after two month storage in ambient temperature whereas at refrigeration temperature the

protein content of salt-smoke-dried control dried tengra and batashi showed a decrease from 65.03 to 60.90, respectively. A study by [6] reported that, the decreasing trend of protein content in hot smoked *C.gariepirrus* during storage period which is in line with the present findings. Similar drop of protein content was reported for smoke-dried chapila, kaika and baim fish during storage at room temperature [13, 10] showed that the protein content of traditionally dried Small Indigenous Species (SIS) products was in the range of 60.78% to 72.59% on dry basis whereas protein content of dried SIS products produced in rotary dryer under room temperature and direct sunlight was in the range of (dry basis) 62.67% to 76.27% and 62.17% to 73.09%, respectively which is more or less similar to the present study.

Minerals contents of all 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 and batashi was decreased from 15.99 to 14.49% while samples kept 60 days at refrigeration temperature, minerals content of salt-smoke-dried (SSD) and control dried (CD) tengra and batashi was decreased to 16.12 to 14.35%, respectively. Smaller sized fish species has higher ash content due to the higher bone of flesh ratio [5]. The ash content obtained for the raw tengra and batashi was also not different from that recorded by [12, 7].

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. At ambient temperature lipid content of salt-smoke-dried and control dried tengra and batashi was varied from 19.07 to 16.01% while the lipid content of salt-smoke-dried and control dried tengra and batashi was found to be decreased 19.54 to 16.16%, respectively at refrigeration temperature. [8] found highest lipid content in *M. vittatus* (17.76%) based on moisture content and 21.54% on dry matter) which is more or less similar to the present study. Present study with tengra and batashi also provides more or less similar result with the findings of the above study. Total Volatile base Nitrogen (TVB-N) is widely used as an indicator of the degree of lipid oxidation [6]. The TVB-N value of fresh tengra and batashi was 1.94 and 1.80 mg/100g, respectively. After smoking TVB-N content increased to 4.69 and 4.25 mg/100g respectively for tengra and batashi fish. TVB-N content further increased after drying and these values were slowly increased during the storage period.

Increase in final values of TVB-N in this study was similar to the result of [10] 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. [4] Reported and also recommended that the limit of acceptability of fish is 20 to 30 mg N/100 g. 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, which are within the accepted limit.

This experiment had shown that the increase of bacterial population in all samples with the increase of storage period. Finding of the present study agree with [17] that reported the total bacterial count decreased after drying, owing to the high salt content and the lack of free water in fish tissues and Coliforms were not present after drying. Moreover, similar findings has also been observed by [11], bacterial count of commercially dried freshwater fish samples ranged from 1.84 x 10^4 to 5.3x10^6 CFU/g. [10] 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 x $l0^8$ CFU/g, 1.9l x $l0^8$ to 2.84 x $l0^8$ CFU/g and l.95 x $l0^8$ to 2.59 x 10^8 CFU/g, respectively. The results obtained on microbial load in the present study are more or less similar as previously reported by [16] for the solar dried products and traditionally dried products.

Conclusion

The present study showed the basic organoleptic, biochemical and microbial information on freshwater small fish; tengra and batashi also provides a possible application of salt-smoke-drying as an effective drying for fish preservation especially in developing countries like Bangladesh where all the required sophisticated storage equipment is not available. 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 shows a better hygienic aspect by shortening the drying period of fish. The overall shelf life of the products prepared by using salt and smoke are longer than plain dried products. From the research findings it can be concluded that the salt-smoke-dried fish products can provides sufficient nutrient to the country people.

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