



Research in

ISSN : P-2409-0603, E-2409-9325

# AGRICULTURE, LIVESTOCK and FISHERIES

An Open Access Peer-Reviewed International Journal

Article Code: 0290/2020/RALF

Res. Agric. Livest. Fish.

Article Type: Research Article

Vol. 7, No. 2, August 2020 : 303-310.

## COMPARATIVE STUDY OF QUALITY ASPECTS AND SHELF LIFE OF SALTED AND UNSALTED SMOKED PRODUCTS FROM SPOTTED SNAKEHEAD (*Channa punctatus*) AT VARIOUS STORAGE CONDITIONS

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### ARTICLE INFO

### ABSTRACT

**Received**

26 June, 2020

**Revised**

18 August, 2020

**Accepted**

24 August, 2020

**Online**

31 August, 2020

**Key words:**

Smoked products  
Spotted snakehead  
Ambient temperature  
Refrigeration temperature  
Quality aspects  
Shelf life

This study was conducted to prepare and evaluate the quality and shelf life of smoked spotted snakehead, taki (*Channa punctatus*) stored at ambient temperature (30-35°C) and refrigeration temperature (4°C) after treating with no salt (T1) and 20% salt (T2). Sensory assessment, initial and final proximate analysis, TVB-N value and microbial analysis (SPC) were carried out for the smoked products stored for different storage periods. According to sensory assessment, smoked taki remained in acceptable condition for 4 and 6 days in T1 and T2, respectively while stored at ambient temperature. However, at refrigeration temperature, smoked taki remained in acceptable condition for 59 and 74 days in T1 and T2, respectively. Biochemical assessment of smoked product showed that protein, lipid and ash content increased due to significant loss of moisture during smoking of fish. No appreciable changes in proximate composition were observed for any of the two storage conditions. Values of TVB-N content of T1 showed rapid increase in comparison to T2 during storage. Microbial load (SPC) of smoked fish decreased due to the smoking process compared to the initial microbial load of fresh fishes but increased with the increase of storage period. Considering all the quality parameters it was found that smoked fish in treatment T2 maintained its excellent quality and longer shelf-life in both storage conditions than treatment T1.

**To cite this article:** Bormon A., S. C. Chakraborty, M. A. Mansur and M. P. Jahan, 2020. Comparative study of quality aspects and shelf life of salted and unsalted smoked products from spotted snakehead (*Channa punctatus*) at various storage conditions. Res. Agric. Livest. Fish., 7 (2): 303-310.



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## INTRODUCTION

Bangladesh is one of the world's leading fish producing countries having total production of 4.276 million metric ton in 2017-18 where aquaculture production contributes 56.24 percent of the total fish production (DoF, 2018). For the first time in the history, Bangladesh became self-sufficient country in fish production through this remarkable achievement with per capita fish consumption of 62.58 g/day (DoF, 2018). During post-harvest period large amount of fish are spoiled and wasted due to lack of proper processing and preservation facilities and also for weak transportation and handling system. So, proper handling, processing and preservation are a prerequisite for minimizing the spoilage loss during post-harvest period (Clucas, 1981). Curing is traditional and popular techniques of fish processing and preservation which generally includes the methods like salting, smoking and drying fish are in principle the reduction of moisture to decrease the water activity (aw) in the muscle. In Bangladesh, generally all these curing methods for fish processing mentioned are well accepted by consumers and popular by the consumers at different levels (Rana, 2016) 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 salting.

Smoking combines six important effects in fish/shrimp muscle such as drying, cooking, preservation, anti-oxidation, color and flavor (Horner, 1992). Small amount of salt softens the texture, improves the flavor, reduces contamination, kills some of the bacteria and protects raw materials against spoilage (Nowsad, 2007). Curing of fish particularly on smoking is being practiced by the smoke drying process of fish (freshwater, coastal river shrimp, small hilsa etc.) in some coastal districts of Bangladesh. These are prepared in small hut like smoke house unscientifically and unhygienically during rainy season when no sunlight is available. This type of smoked product may be used as one of the popular value added product at a large scale if it is made properly and hygienically. Therefore study related to quality and shelf-life of products is necessary for preparing a value added product like salt smoked product from different types of fish. The hot smoke-fish product is a ready to eat product and proper hygienic condition is a must in all its processing steps. With time, people of Bangladesh are being acquainted with different fish products. The consumer's preference were showed by testing some smoke cured and salt-smoke cured fish with native species prepared experimentally for this tasty product as encouraging (Salim *et al.* 2007, Rana, 2016). Spotted snakehead, taki (*Channa punctatus*) is highly valued, widely available and popular food fish with high protein and less boned Salt-smoked new quality product (brining and smoking) from taki fish would hopefully be considered as one of the popular demand food items in the country. That's why spotted snakehead, taki (*Channa punctatus*) have been selected for the present research work with an aim to produce and find the potentiality of salt-smoked and unsalted smoked fish product to serve as one of the well-accepted quality fishery products showing a longer shelf life kept at ambient and refrigeration temperature.

## MATERIALS AND METHOD

For the experiment, taki, spotted snakehead (*Channa punctatus*) were collected from local markets (K.R. market, Bangladesh Agricultural University) and transferred to the laboratory of Fisheries Technology, Bangladesh Agricultural University. After washing with potable water, weighed whole fish were dressed, filleted and washed. 7 fish of spotted snakehead were immersed into a plastic bucket containing 20% salt solution for 10 min. For the completion of ambient drying the fishes were left in room temperature for about 10 minutes. After air drying, the fillets were hanged inside the smoking kiln with the help of metallic "S" shaped hook in the upper smoking chamber of the kiln. About 3-4 inches small bamboo sticks were set horizontally within each fillets. 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. The temperature inside the kiln was maintained manually by using a sensitive. Smoking was done approximately 1.5 hours until the desired color and flavor obtained. The products were allowed to cool for 15-20 minutes at room temperature (30-35°C) after smoking. The smoked products were packed in transparent polythene bags and were sealed. The packaged fishes were divided into two groups for storage- one part was kept at ambient temperature (30-35°C) and other part was kept at refrigeration temperature (4°C) for comparing their shelf-life and acceptability.

Sensory evaluation was carried out to assess the degree of freshness of smoked products such as color, flavor, odor and texture etc. to determine the quality changes during storage of smoked spotted snakehead (*C. punctatus*). Sensory evaluation was carried out daily for the samples stored at ambient temperature (30-35°C) and 10 days interval for refrigeration temperature (4°C) using a 9-point hedonic scale for evaluating the degree of freshness until it was considered acceptable by the method of Larmond (1977). Organoleptic characteristics of the stored fish were tested by a panel of five members for acceptability of the products during the described periods. TVBN content and proximate composition analysis namely determination of moisture, crude protein, lipid and ash was carried out according to the methods given in AOAC (1990). Proximate analyses of smoked products were done on 1<sup>st</sup>, 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup>, 75<sup>th</sup> day when the products were kept at refrigeration temperature. Proximate analysis was done on 1<sup>st</sup>, 3<sup>rd</sup>, 5<sup>th</sup> and 7<sup>th</sup> day for the products stored at ambient temperature. Standard Plate Count (SPC) was used for total plate count of smoked products.

## RESULTS AND DISCUSSION

The organoleptic parameters of the samples were rated as good at the beginning of storage based on the grading scale. On the 1<sup>st</sup> day of preparation of the spotted snakehead smoked products, it was seen that the products had bright golden yellow color with fresh salted smoky flavor of firm, elastic texture showing extremely attractive appearance. These qualities became changed with increase of time period and the products were rejected when the product had dull brown color with comparatively disagreeable odor with soft texture having unacceptable appearance showing salty unpleasant taste while stored at ambient temperature which was marked as mean general acceptability score (Table 1). Similar characteristics were found in the smoked products at refrigeration temperature (Table 2). The highest mean acceptability score was found 8.67 in T1 and 8.98 in T2 of smoked spotted snakehead. The mean acceptability score decreased with the increase of the storage duration. In case of smoked products of spotted snakehead, product in T1 kept at control condition was found acceptable up to a period of four days and was considered rejected on the 5<sup>th</sup> day of observations at ambient temperature storage condition. Mean general acceptability score of T1 were 3.72 at 4<sup>th</sup> day and 2.62 at 5<sup>th</sup> day of storage. Fungal growth was seen in the products at the 5<sup>th</sup> day of storage (Figure 01). The fish in T2 showed its acceptability up to 5 days, whereas on the 6<sup>th</sup> day it was just satisfactory and on the 7<sup>th</sup> day fungal growth was seen on the fish tissue (Figure 1), thus was rejected with mean acceptability score of 2.49. Shakhawat (2010) found similar result about smoked tilapia proved that the convenient temperature and available moisture content favors the rapid growth of fungus on smoked products kept at ambient temperature.

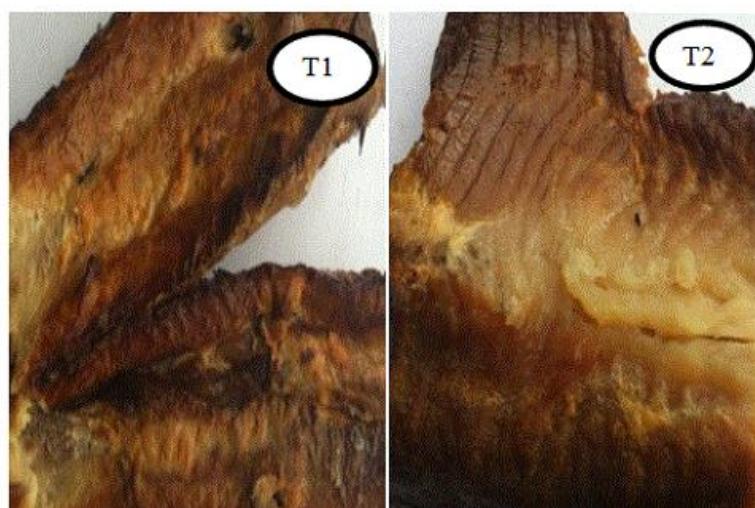
**Table 1.** General mean acceptability scores of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) on different days of storage at ambient temperature (According to Larmond, 1977) based on 9 point scoring scale

Observation period (days)	Color		Flavor		Texture		General appearance		Taste		Mean of general acceptability	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1 <sup>st</sup>	9	9	8.59	8.97	8.70	8.98	8.97	9	7.78	8.97	8.67	8.98
2 <sup>nd</sup>	7.79	7.81	7.56	7.95	7.70	7.75	7.77	7.99	6.56	7.85	7.48	7.87
3 <sup>rd</sup>	6.1	6.60	5.99	6.79	5.75	6.89	5.64	6.90	5.35	6.78	5.77	6.79
4 <sup>th</sup>	3.5	5.50	3.65	5.45	3.60	5.55	3.90	5.65	3.95	5.70	3.72	5.57
5 <sup>th</sup>	2.24	4.58	2.46	4.44	2.26	4.97	2.39	4.78	3.75	4.79	2.62	4.71
6 <sup>th</sup>		3.30		3.47		3.65		3.61		3.54	-	3.51
7 <sup>th</sup>		2.52		2.34		2.37		2.77		2.43	-	2.49

\*Nice and attractive: ≥ 7; Acceptable: ≥ 4; Just satisfactory: 3 to below 4; Rejected: ≤ 3



**Figure 1.** Appearance of fungus in sample of T1 and T2 on 5<sup>th</sup> and 7<sup>th</sup> day respectively in case of smoked taki (*Channa punctatus*) stored at ambient temperature (30-35°C)



**Figure 2.** Appearance of fungus in sample of T1 and T2 on 60<sup>th</sup> and 75<sup>th</sup> day respectively in case of smoked taki (*Channa punctatus*) stored at refrigeration temperature (4°C)

At refrigerated storage condition, the product in T1 of smoked taki showed its acceptability up to 50<sup>th</sup> day whereas it was just satisfactory up to 59<sup>th</sup> day and reached the condition of rejection on 60<sup>th</sup> day (Figure 2) when mean general acceptability score was 2.39. In case of T2, the product showed its acceptability up to 60<sup>th</sup> day, it was just satisfactory until 74<sup>th</sup> day and was rejected on 75<sup>th</sup> day due to appearance of fungal growth on the fish tissue (Figure 2) with poor mean acceptability score of 2.32. It was observed that the mean acceptability score was inversely related with storage period. The results of this experiment were in agreement with the previous research works of Rakhi (2012) and Chowdhury (2017). The smoked products without salt treated (controlled) were more perishable than the products dipped in 20% salt concentration because salt delayed the growth of fungus. The refrigerated product showed longer shelf-life than the products stored at ambient temperature (30- 35°C) because low temperature prevents the rapid growth of fungus.

**Table 2.** General mean acceptability scores of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) on different days of storage at Refrigeration temperature (According to Larmond, 1977) based on 9 point scoring scale

Observation period (days)	Color		Flavor		Texture		General appearance		Taste		Mean of general acceptability	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
1 <sup>st</sup>	9	9	8.59	8.97	8.70	8.98	8.97	9	7.78	8.97	8.67	8.98
10 <sup>th</sup>	8.24	8.81	8.56	8.45	8.30	7.75	8.77	8.79	8.06	8.65	8.39	8.49
20 <sup>th</sup>	7.58	7.80	6.99	7.79	7.75	7.19	7.14	7.80	7.25	7.91	7.34	7.69
30 <sup>th</sup>	7.07	7.50	6.20	7.25	6.43	6.55	6.18	7.15	6.29	7.55	6.43	7.2
40 <sup>th</sup>	6.14	6.58	5.86	6.76	6.09	5.97	5.67	6.58	5.54	6.89	5.86	6.56
50 <sup>th</sup>	4.53	5.56	4.26	5.33	4.75	5.21	4.28	5.36	3.69	6.25	4.30	5.54
60 <sup>th</sup>	2.33	4.10	2.19	4.99	2.56	4.12	2.27	4.11	2.64	5.95	2.39	4.65
70 <sup>th</sup>	-	3.45	-	3.19	-	3.67	-	3.45	-	3.68	-	3.49
75 <sup>th</sup>	-	2.15	-	2.34	-	2.88	-	2.21	-	2.01	-	2.32

\*Nice and attractive:  $\geq 7$ ; Acceptable:  $\geq 4$ ; Just satisfactory: 3 to below 4; Rejected:  $\leq 3$

**Table 3.** Results of proximate analysis of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) stored at ambient temperature (30-35°C)

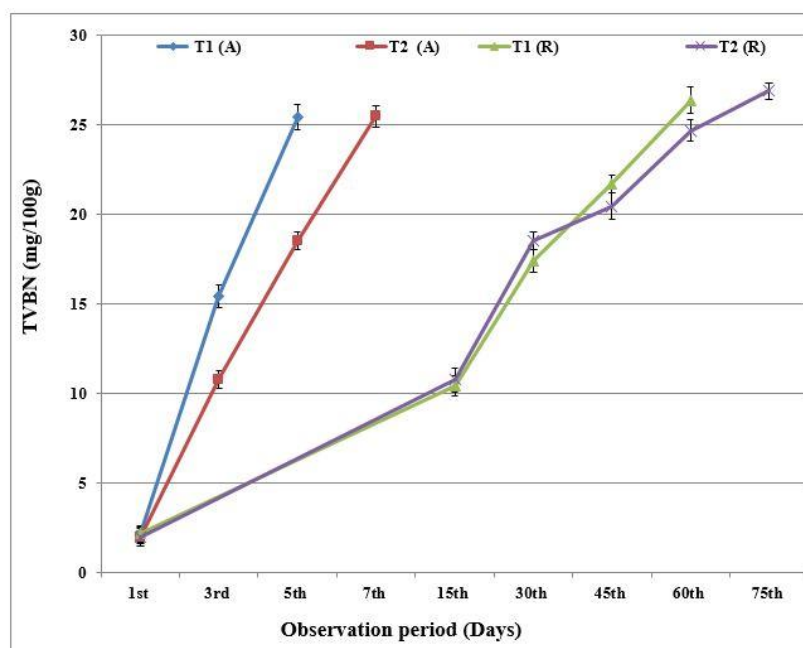
Storage period (Days)	Moisture (%)		Ash (%)		Protein (%)		Lipid (%)	
	T1	T2	T1	T2	T1	T2	T1	T2
1 <sup>st</sup>	67.55 $\pm$ 0.51	63.81 $\pm$ 0.45	2.91 $\pm$ 0.25	4.8 $\pm$ 0.35	25.37 $\pm$ 0.52	26.55 $\pm$ 0.25	4.15 $\pm$ 0.28	4.81 $\pm$ 0.13
3 <sup>rd</sup>	67.63 $\pm$ 0.35	63.95 $\pm$ 0.62	2.92 $\pm$ 0.19	4.82 $\pm$ 0.17	25.32 $\pm$ 0.36	26.48 $\pm$ 0.43	4.12 $\pm$ 0.15	4.78 $\pm$ 0.25
5 <sup>th</sup>	67.76 $\pm$ 0.42	64.1 $\pm$ 0.35	2.93 $\pm$ 0.31	4.85 $\pm$ 0.24	25.26 $\pm$ 0.48	26.41 $\pm$ 0.34	4.08 $\pm$ 0.16	4.74 $\pm$ 0.19
7 <sup>th</sup>	-	64.24 $\pm$ 0.29	-	4.87 $\pm$ 0.28	-	26.35 $\pm$ 0.50	-	4.71 $\pm$ 0.32

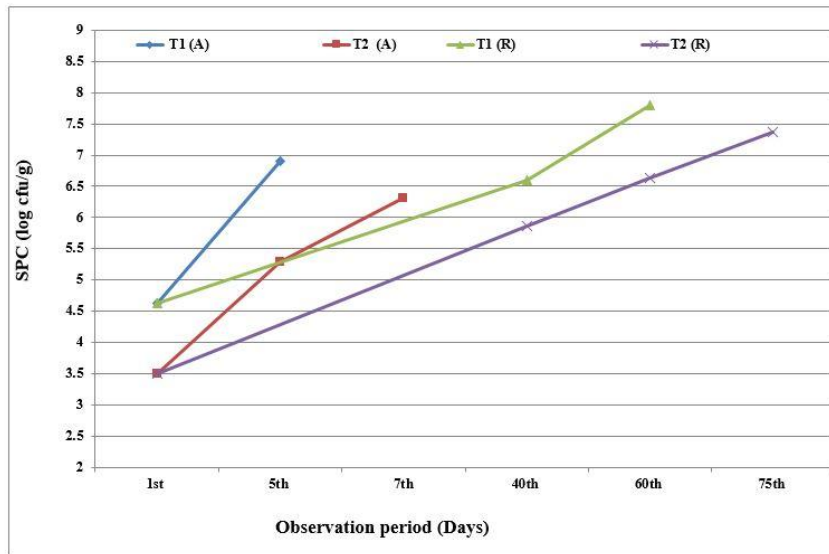
In fresh taki, the mean moisture, protein, lipid and ash content were found to be 75.78%, 20.03%, 2.004% and 2.16% respectively. After smoking, moisture, ash, protein and lipid content of T1 were 67.55 $\pm$ 0.51%, 2.91 $\pm$ 0.25%, 25.37 $\pm$ 0.52% and 4.15 $\pm$ 0.25%, respectively. For T2 the values of these compositions were 63.81 $\pm$ 0.45%, 4.80 $\pm$ 0.35%, 26.55 $\pm$ 0.25% and 4.81 $\pm$ 0.31%, respectively. After 5 days of storage at ambient temperature, values of moisture, ash, protein and lipid content were 67.76 $\pm$ 0.42%, 2.93 $\pm$ 0.31%, 25.26 $\pm$ 0.48% and 4.08 $\pm$ 0.16% for T1 and 64.1 $\pm$ 0.35, 4.85 $\pm$ 0.24%, 26.41 $\pm$ 0.34%, 4.74 $\pm$ 0.19% for T2, respectively (Table 3). On the 60<sup>th</sup> day of storage at refrigeration temperature moisture, ash, protein and lipid content of T1 were 68.01 $\pm$ 0.25%, 2.95 $\pm$ 0.23%, 25.22 $\pm$ 0.25% and 4.08 $\pm$ 0.35%, respectively (Table 4). In case of T2 stored at refrigeration temperature, products were in acceptable condition till 75<sup>th</sup> day when moisture, ash, protein and lipid content were 64.31 $\pm$ 0.38%, 4.9 $\pm$ 0.32%, 26.15 $\pm$ 0.15% and 4.67 $\pm$ 0.25%, respectively. Moisture content decreased during smoking process in smoked products of different treatments from initial values due to high heat. In this experiment, the ash content increased after smoking because salt content increased from fresh sample due to reduction of moisture and smoked products contain large amount of inorganic salt compared to fresh samples. For the same reason lipid and protein content were also increased in the products immediately after smoking. Due to the difference in the moisture content of the smoked fish and the surroundings, there was a little increase in the moisture content of smoked fish stored at both temperatures. Ash content of T2 was higher than that of T1 due to the pretreatment using 20% salt. Changes in protein and lipid content in both treatments at two storage conditions were not significant. The present experiment with spotted snakehead gives more or less similar results with the findings of Debnath *et al.* (2009), Gopal (2005) and Shakhawat (2010).

**Table 4.** Results of proximate analysis of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) stored at refrigeration temperature (4°C)

Storage period (Days)	Moisture (%)		Ash (%)		Protein (%)		Lipid (%)	
	T1	T2	T1	T2	T1	T2	T1	T2
1 <sup>st</sup>	67.55±0.35	63.81±0.51	2.91±0.25	4.80±0.34	25.37±0.50	26.55±0.52	4.15±0.25	4.81±0.31
15 <sup>th</sup>	67.64±0.52	63.91±0.35	2.92±0.32	4.82±0.23	25.34±0.26	26.49±0.35	4.13±0.33	4.77±0.25
30 <sup>th</sup>	67.72±0.23	64.02±0.24	2.93±0.18	4.84±0.17	25.3±0.43	26.4±0.41	4.11±0.43	4.75±0.32
45 <sup>th</sup>	67.83±0.54	64.1±0.46	2.94±0.27	4.86±0.25	25.26±0.32	26.31±0.29	4.09±0.29	4.72±0.37
60 <sup>th</sup>	68.01±0.25	64.2±0.56	2.95±0.23	4.88±0.38	25.22±0.25	26.24±0.22	4.08±0.35	4.69±0.31
75 <sup>th</sup>	-	64.31±0.38	-	4.9±0.32	-	26.15±0.15	-	4.67±0.25

TVB-N values of fresh spotted snakehead were 1.89 mg/100g. The TVB-N values were found to be increased to 2.19±0.45mg/100g in T1 and 2.01±0.34 mg/100g in T2 before storage. On 5<sup>th</sup> day of observation the TVB-N values were 25.41±0.73 mg/100g in T1 and 25.45 ±0.61mg/100g in T2 stored at ambient temperature (Figure 03). On the other hand, the TVB-N values were 26.34±0.75 mg/100g in T1 and 24.65±0.59mg/100g in T2 on 60<sup>th</sup> day of observation at refrigerated temperature (Figure 3). These results coincide with the results of Debnath *et al.* (2009) and Gopal (2005). Pearson (1982) and Connell (1995) also opined that the acceptability limit of fish is 20 to 30 mgN/100 g. Samples stored at ambient temperature showed more rapid increase in TVB-N values compared to samples kept at refrigerated storage temperature. This might be due to rapid breakdown of protein and favorable condition for microbial and enzymatic activity during storage at ambient temperature which slows down at low temperature preservation.

**Figure 3.** Changes in TVB-N content (mg/100g) of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) at ambient temperature (A) and refrigeration temperature (R)



**Figure 4.** Changes in SPC (log CFU/g) of unsalted (T1) and 20% salt treated smoked spotted snakehead (T2) at ambient temperature (A) and refrigeration temperature (R)

Bacterial load in fresh tiki was  $1.55 \times 10^6$  CFU/g. In smoked fillets of tiki of T1 and T2; the bacterial loads were  $4.3 \times 10^4$  CFU/g and  $3.13 \times 10^3$  CFU/g respectively before storage. Bacterial load of the products was reduced due to high heat during smoking. Value of Standard Plate Count (SPC) increased to  $8.1 \times 10^6$  CFU/g in T1 and  $1.95 \times 10^5$  CFU/g in T2 on 5<sup>th</sup> day of storage at ambient temperature (Figure 04). For the samples kept at refrigeration temperature the SPC were found  $6.31 \times 10^7$  CFU/g in T1 and  $4.37 \times 10^6$  CFU/g in T2 of on 60<sup>th</sup> day of storage (Figure 4). Similar result was found by Debnath *et al.* (2009). Total bacterial load in both treatments increased rapidly with the increase of storage time and reached maximum at unacceptable limit and it was considered as spoiled. Bacterial growth in the samples stored at refrigeration temperature was slower than the products stored at ambient temperature because in the country like Bangladesh bacteria works very slowly in low temperature. Bacterial load in T2 is lower than that of T1 due to the presence of salt. Salt inhibits the growth of bacteria (Nowsad, 2007). In Bangladesh, BSTI (1982) recommended the SPC of processed fish to be not more than  $10^6$  CFU/g. If any sample contains more than  $10^8$  CFU/g bacterial counts then these microbes can cause spoilage of that product (Ojagh *et al.*, 2010).

## CONCLUSION

The shelf-life of smoked fish in two treatments was affected by storage conditions. At lower temperature there was longer shelf-life while at ambient temperature there was shorter shelf-life. Salt treatment in fish slightly affected the level of lipid oxidation although smoking exhibited greater antioxidant activity. The changes in protein content was affected by brine, 20% salt dipped samples had higher protein, lipid, ash and lower moisture content compared to the controlled smoked (with no salt) products. Different nutritional components of fish were undergone different changes insignificantly at different storage condition. The experiment therefore, concludes that compared to unsalted fish, salt treated spotted snakehead, tiki (*Channa punctatus*) fillet (T2) would produce a good quality acceptable smoked product with longest shelf-life kept at both ambient (30-35°C) and refrigeration temperature (4°C). Salt treated smoked products stored at refrigeration temperature showed longer shelf life than that of products stored at ambient temperature.

## COMPETING INTEREST

The authors declare no competing interests.

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