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EFFECT OF SALT AND SMOKE ON QUALITY AND SHELF LIFE OF SALT-SMOKE-DRIED BATASHI (*Neotropius atherinoides*) KEPT AT DIFFERENT STORAGE CONDITION

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ABSTRACT

This study was carried out to assess the changes in microbiological and biochemical aspects of fresh, smoked, salt-smoke-dried (SSD), control dried (CD; treated without salt and smoke) batashi (*Neotropius atherinoides*) during storage at ambient temperature (26-28°C) and refrigeration temperature (4°C). The main objective of this study was to investigate the effect of natural preservatives such as salt and smoke on the shelf life of the product over the storage period. The moisture content of fresh batashi was 75.81% whereas 18.10% for SSD batashi. The initial value of protein, fat and ash content of SSD batashi was 65.93, 17.09 and 16.90% on dry matter basis. During storage period (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 batashi were 65.0, 15.9 and 15.95%, respectively whereas the values of the same parameters stored at refrigeration temperature were 65.03, 16.16 and 16.12%, respectively on dry matter basis. The initial TVB-N and SPC value for SSD batashi was 6.10mg/100g and 1.14×10^4 CFU/g respectively. During storage period TVB-N and SPC value slowly increased and the values reached to 17.94 mg/100g and 4.2×10^4 CFU/g, respectively for salt-smoke-dried batashi, stored at ambient condition whereas 11.20 mg/100g and 2.42×10^4 CFU/g, respectively for the products stored at refrigeration temperature. Because of using salt and smoke as natural preservatives, no yeast or mould was detected in salt-smoke-dried batashi fish. Therefore, it can be inferred that salt and smoke treated dried fish products has longer shelf life than plain dried product (without treated with salt and smoke). From the overall performance, the products kept at refrigeration temperature showed better shelf life than the products stored at ambient temperature.

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INTRODUCTION

Fish provides a high source of protein required in the diets of man as it contains essential nutrients such as vitamins, fats and minerals which help in the maintenance of life (Ashano and Ajayi, 2003). 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. 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. In other words, proper handling, processing and preservation during post-harvest period are a prerequisite for minimizing the spoilage loss (Clucas, 1981). The processing and preservation of fresh fish is most important since fish is highly susceptible to deterioration immediately after harvest and also to prevent economic losses. Fish Smoking is one of the traditional fish processing methods aimed at preventing or reducing postharvest losses. Smoking involves heat application to remove moisture and it inhibits bacterial and enzymatic actions of fish (Kumolu-Johnson *et al*., 2009) enhance flavor and increase utilization of the fish (Nahid *et al.*, 2016). There are many factors e.g. brine concentration, smoking time, smoke temperature, types of fish species, types of smoke source etc. responsible for the shelf-life and quality of the smoked fish (Salim *et al.*, 2007). 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 ready to eat product 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 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 with characteristic flavor and taste to be preferred by the consumers.

There has been very limited reported work on fish smoking in Bangladesh. In Bangladesh smoked fish is recent addition to the fishery products. Preservation of Small Indigenous Species (SIS) fish is comparatively a new trend or new kind of research activities in this country. Due to high palatable, taste and rich in nutrients freshwater SIS such as batashi (*Neotropius atherinoides*) have been selected for the present research work with an aim to produce salt-smoke-dried fish product to serve as one of the better-accepted quality fishery products showing a longer shelf life when kept at ambient and refrigeration temperature.

MATERIALS AND METHODS

Sample Collection

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

Washing and Dressing of Fish

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

Brining, dewatering, air drying and pre-smoking treatment

After draining out water the fishes were allowed for salt treatment. The fishes were immersed into a plastic bucket containing 25% salt solution for 5 min. after that kept the fishes 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.

Smoking

The lower chamber of the smoking kiln had the facilities of burning saw dust or wood chips on an iron bowl so to produce a continuous and a homogenous hot smoke. The temperature inside the smoke chamber was recorded at every 10 minutes and the temperature was controlled by the exit cover of the kiln. 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 middle period, by using a corrosion free metal element to make the sample smooth and steady in texture and appearance. After smoking, products were cooled for 15-20 minutes at room temperature. Cooling firmed the muscle and facilitated to prevent breaking of smoked fish.

Drying Procedure

The smoked fish was than dried with the help of a Ring tunnel dryer. The structure of Ring tunnel is very simple compared to other dryer (Solar tunnel dryer, Rotary dryer). A 6.5 to 7 feet long piece of bamboo was splitted equally in to 6-7 parts the rear end unsplitted. Several rings (outer rings) 1-15 ft diameters were made of split bamboo were tied 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 (Plate 1). The vertical distance between two sieves was about 1.7 feet. Four sieves with similar manner were fixed inside the circular frame. Small fishes were spreaded on these sieves inside the ring tunnel carefully for sun drying. The tunnel was installed vertically keeping the unspiltted bamboo at the upside. After loading of the trays with smoked fish all sides of the tunnel was carefully covered by the polythene except a little whole was kept open at the upper portion of the ring tunnel for the exit of warm air.

Plate 1. Ring tunnel dryer (unloaded) **Plate 2.** Ring tunnel dryer (operational view)

The ring tunnel containing the smoked fish was placed at the eastern side of the roof of Prof. Aminul Haque building in the faculty of Fisheries, Bangladesh Agricultural University, Mymensingh to ensure day-long continuous sunshine on the fish in ring tunnels (Plate 2). Temperature inside and outside the ring tunnels during the whole day of drying period of batashi fishes were recorded carefully with the help of a sensitive thermometer. The process continued till the completion of drying. For complete drying of batashi took about 3days (18-20) hours until the final products had moisture level of less than around 20%.

Packaging, Leveling and Storage of the salt-smoke-dried fish products for quality and shelf life study

The smoke-dried fishes were packed in polythene bag and was sealed using an electrical sealing machine (PFS-300) to prevent moisture absorption. Each bag contained 100g salt-smoke-dried fishes with proper labeling to be used for further analysis. 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).

Plate 3. Salt-smoked batashi fish product

Plate 4. Salt-smoke-dried batashi fish product

Analysis

For quality and shelf life analysis sampling was done on every 15 days interval for the sample kept at ambient and refrigeration temperature. The nutritional quality on proximate composition (moisture, crude protein, lipid and ash) of the fresh and salt-smoked, salt-smoked dried and control dried fish was carried out in triplicate according to AOAC 1990. Total bacterial count of fresh, salt-smoked, salt-smoke-dried and control dried fish samples were done on nutrient agar media by Standard Plate Count (SPC) method. This method consists of growing the bacteria in a nutrient culture petridish and counting the colonies in the petridish which developed at defined incubation period (35-37°C for 48 hours).

RESULTS AND DISCUSSION

In the present study, it shows the concentration of biochemical composition and microbial populations in fresh, smoked, salt-smoke-dried and control dried batashi fish samples.

Result of Nutritional Quality Analysis

The values of crude protein, lipid and ash have been expressed as dry weight basis. There was a gradual increase in the moisture content of these two types of products with increasing storage period in both ambient and refrigeration condition (Table 1 and 2). This result coincides with the findings of Nahid *et al. (*2014, 2016) and Mazumder *et al.* (2008) in *A. mola, P. chola, G. chapra* and in *P. atherinoides.* On the other hand moisture content increased slowly for the products stored at refrigeration temperature and the values increased from 18.10 (1st day) to 21.42% (60 day) for salt-smoke-dried batashi and from 18.54 (1st day) to 22.86% (60 day) (Table-2) Such increase in moisture content these types of products might be 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 (Nahid *et al*., 2016) during storage at room temperature which is more or less similar with the present study. The shelf life of both the two types of showed more or less similar with the observation of Jallow who stated that fish at 10-15% moisture content reportedly had a shelf life of 3-9 months when stored properly (Jallow, 1995).

The crude protein content of salt-smoke-dried (SSD) and control dried (CD) product on 0 day was 65.93 and 65.50 %(dry matter basis) respectively. This concentration was resulted from the loss of moisture by the smoking process as opined by Koral *et al.* (2009). Protein decomposes with passing time (Ghezala, 1994).The protein content of salt-smoke-dried (SSD) and control dried (CD) batashi decreased to 65.0 and 58.96%, respectively on dry matter basis after two month storage at ambient temperature. After two month stored at refrigeration temperature the protein content of salt-smoke-dried control dried batashi showed a small decrease

to 65.03 and 62.80% on dry matter basis, respectively. 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 *Clarius gariepinus* during storage period which is more or less similar with the present findings.

Table 1. Proximate composition (dry weight basis), TVB-N and bacterial count of Fresh, Salt-Smoked, Salt-Smoke-Dried and Control Dried Batashi Fish Stored at Ambient Temperature (26-28) ^{0}C

Day of Observation	Products Name	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/g.)
0	Fresh fish	75.81±0.18	64.65±0.70	15.71±0.29	13.23±0.57	1.80±0.32	2.72×10^5
0	Salt-smoked fish	61.65±0.13	65.95±0.29	16.84±0.29	12.57±0.16	4.25±0.26	2.64×10^4
0	SSD	18.10±0.11	65.93±0.17	17.09±0.17	16.90±0.06	6.14±0.18	1.14×10^4
0	CD	18.54±0.18	65.50±0.21	18.02±0.17	16.27±0.50	7.05±0.46	1.88×10^4
15	SSD	18.86±0.17	65.54±0.07	16.91±0.25	16.69±0.16	8.82±0.38	1.8×10^4
15	CD	18.78±0.30	65.08±0.14	17.88±0.44	15.63±0.34	9.46±0.46	2.64×10^4
30	SSD	20.14±0.06	65.44±0.04	16.43±0.08	16.23±0.04	11.68±0.42	2.32×10^4
30	CD	20.16±0.22	64.98±0.18	17.46±0.55	15.21±0.11	13.46±0.14	3.9×10^4
45	SSD	21.64±0.03	65.08±0.40	16.18±0.26	16.08±0.09	15.76±0.54	2.9×10^4
45	CD	21.10±0.09	64.36±0.42	17.11±0.58	15.03±0.30	16.14±0.33	4.68×10^4
60	SSD	23.26±0.06	65.0±0.09	15.9±0.33	15.95±0.22	17.94±0.21	4.2×10^4
60	CD	26.30±0.34	58.96±0.84	16.01±0.08	14.49±0.39	19.42±0.42	2.5×10^5

Table 2. Proximate composition (dry weight basis), TVB-N and bacterial count of fresh, salt-smoked, salt-smoke-dried and control dried batashi fish stored at refrigeration temperature (4) ^{0}c

Day of Observation	Products Name	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N (mg/100g)	SPC (CFU/g.)
0	Fresh fish	75.81±0.18	64.65±0.70	15.71±0.29	13.23±0.57	1.80±0.32	2.72×10^5
0	Salt-smoked fish	61.65±0.13	65.95±0.29	16.84±0.29	12.57±0.16	4.25±0.26	2.64×10^4
0	SSD	18.10±0.11	65.93±0.17	16.84±0.29	12.57±0.16	5.86±0.22	1.14×10^4
0	CD	18.54±0.18	65.50±0.21	17.09±0.17	16.90±0.06	6.88±0.05	1.88×10^4
15	SSD	18.32±0.14	65.82±0.13	18.02±0.17	16.27±0.50	6.24±0.11	1.36×10^4
15	CD	19.87±0.14	64.89±0.52	16.99±0.28	16.75±0.09	7.24±0.18	1.96×10^4
30	SSD	19.20±0.21	65.64±0.20	17.82±0.26	16.07±0.44	7.16±0.23	1.64×10^4
30	CD	20.28±0.22	64.15±0.40	16.34±0.17	16.21±0.24	9.34±0.26	2.84×10^4
45	SSD	20.05±0.17	65.32±0.08	17.53±0.30	15.08±0.26	8.96±0.14	2.2×10^4
45	CD	21.86±0.48	63.75±0.49	16.24±0.35	16.16±0.39	11.45±0.14	3.10×10^4
60	SSD	21.42±0.25	65.03±0.17	17.28±0.28	14.89±0.59	11.81±0.39	2.42×10^4
60	CD	22.86±0.58	62.80±0.65	16.16±0.45	16.12±0.09	15.08±0.24	1.16×10^5

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

The initial lipid content of salt-smoke-dried batashi was high compared to the fresh fish. After smoke-drying, there was an increase in fat content and this variation could be result of evaporation of moisture contents which is in agreement with the previous research works of Ogbonnaya and Shaba (2009), Darmola et al. (2007), Bouriga et al. (2012) and Biligin et al. (2008). Lipid content of salt-smoke-dried (SSD) and control dried (CD) batashi was 17.09 and 18.02%, respectively on dry matter basis, immediately after preparation. 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 batashi was decreased to 15.9 and 16.01%, respectively on dry matter basis. On the other hand, products stored at refrigeration temperature lipid content of salt-smoke-dried

and control dried batashi was found to be decreased to 16.16 and 16.77%, respectively on dry matter basis. Similar decreasing trend of lipid content was found in salt and garlic treated smoke-dried chapila and guchi baim (Nahid et al., 2014). Usually moisture and fat contents in fish flesh are inversely related and there sum is approximately 80% (FAO, 1999) which is well defined in this research findings.

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. At 1st day of observation ash of salt-smoke-dried and control dried batashi was 16.90 and 16.27%, respectively. After two month storage at ambient temperature ash content of salt-smoke-dried and control dried batashi was decreased to 15.95 and 14.49, respectively. On the other hand, samples kept 60 days at refrigeration temperature, ash content of salt-smoke-dried (SSD) and control dried (CD) batashi was decreased to 16.12 and 14.35%, (on dry matter basis), respectively. Smaller sized fish species has higher ash content due to the higher bone to flesh ratio (Darmola et al., 2007).

TVB-N (mg/100g) value

In this study the higher value of TVB-N were reported in fresh salt-smoke-dried, control dried batashi compared with fresh fish. There was continuous increase in TVB-N value of all smoke-dried products throughout the storage period (Figure 1) 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 6.14 (1st day) to 17.94mg/100g (60 day) for salt-smoke-dried batashi, 7.05 (1st day) to 19.42mg/100g (60 day) for control dried batashi. On the other hand products stored at refrigeration temperature the TVB-N values were found varied between 6.14 (1st day) to 11.20 mg/100g (60 day) for salt-smoke-dried batashi, 7.05 (1st day) to 12.84 mg/100g (60 day) for control dried batashi. 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.

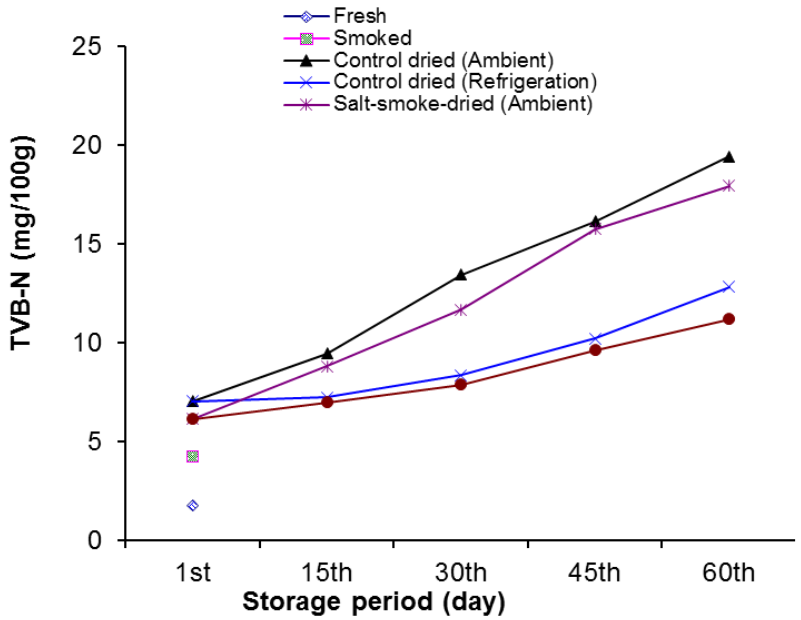

Figure 1. Changing pattern of TVB-N content (mg/100g) of batashi with different treatments stored at ambient (26-28°C) and refrigeration (4°C) temperature

Pearson (1982) and Connell (1995) recommended that the limit of acceptability of 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).

Microbiological Quality Analysis

Bacterial load in fresh batashi was found 2.72×10^5 CFU/g, after smoking bacterial load reduced to 2.64×10^4 CFU/g. 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 1.14×10^4 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 of storage at ambient temperature was 4.2×10^4 and 2.5×10^5CFU/g for salt-smoke-dried and control dried batashi, respectively (Figure 2). On the other hand value of SPC for the products stored at refrigeration temperature were increased to $2.42\times\times10^4$ and 1.16×10^5 CFU/g for salt-smoke-dried and control dried batashi, respectively. The CFU/g of smoke-dried fish samples increased with increase in storage period 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 lack of enough free water in fish tissues.

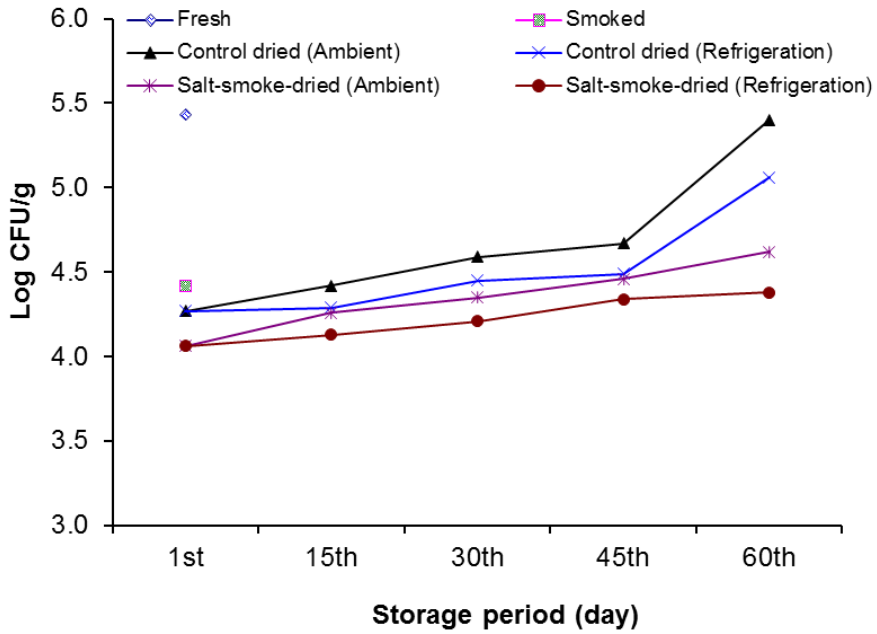

Figure 2. Changing pattern of bacterial load (log CFU/g) of batashi with different treatments stored at ambient (26-28°C) and refrigeration (4 °C) temperature

Similar findings has also been observed by Kamruzzaman (1992) where bacterial count of commercially dried freshwater fish samples ranged from $1.84\text{x}10^4$ to $5.3\text{x}10^6$ CFU/g. Hasan *et al.* (2006) showed that much higher 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, $1.9\text{l}\times\text{l}0^8$ to $2.84\times\text{l}0^8$ CFU/g and $\text{l}.95\times\text{l}0^8$ to 2.59×10^8 CFU/g, respectively. This experiment with batashi also provides more or less similar result with the findings of the above studies.

CONCLUSION

Salt-smoke-dried SIS (batashi) produced in smoking kiln and 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 showed a better hygienic aspect by shortening the drying period of fish. The saving of time and improvement of the quality in the salt-smoke-dried fish process will help the poor fisher folks getting better price for their products but also enhance consumer preference in the local market as well as export market. One of the major findings from the present study was the effect of salt and smoke on the insects (flies). Fish treated with only salt was seen to be infested by few insects, whereas no infestation was seen in fish treated with salt and smoke on the other hand fish which were not treated with salt and smoke (control), the product was infested by insect during drying in open place.

COMPETING INTEREST

The authors declare no competing interests.

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