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Effects of Salting on the shelf lives extension of sun-dried Shoal (*Channa striatus* Bloch, 1801) and Taki (*C. punctatus*; Bloch, 1793) fish-products stored at room temperature (27°C - 30°C)

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Abstract

Keeping the quality of fish and fish products at its best is the most important issue in any kind of fish processing. Among them, Drying of fish (dried fish-product called 'shutki' in Bangladesh) is widely used as a traditional method for preservation and considered as a concentrated source of nutrients to Bangladeshi people. So, an experiment was carried out to assess the sensory-evaluation and changes in chemical-compositions of sun-dried salted (SDS) Shoal and Taki fish products stored at room temperature. TVB-N, pH and FFA value increased significantly ($p < 0.05$) with the time of storage period and between these two salted products, these parameters rapidly increased in SDS Shoal than SDS Taki fish and at the end of 5 months SDS Shoal fish product became spoiled whereas SDS Taki fish still in fresh condition. TVB-N value was found below the range suggested by various researchers for fish and fish-products.

Keywords: Sun-dried-Salting, Shoal, Taki, Quality-evaluation

1. Introduction

It has been estimated that about 80% of the animal protein in the diet of most people in Bangladesh comes from fish alone [1]. Fresh and dried fish are a popular food in the world, including Bangladesh [2].

The purpose of processing and preservation fish is to get fish to an ultimate consumer in good and acceptable condition. Inadequate preservation techniques would imply a substantial shortfall in fish availability thereby affecting the protein intake [3]. In order to reduce the wastage and spoilage of fish during periods of oversupply, and to enhance long storage, it is necessary to adopt appropriate as well as affordable processing and preservation techniques for fish. Traditional fish processing is an important livelihood activity for large number of people in Bangladesh. The common fish preservation methods are salting, smoking, icing, freezing, drying etc. Of these methods of preservations, drying is one of the most important methods throughout the world. It is a common practice in meat, fish and other animal protein based industry, because it preserved the quality for an extended time and offers several advantages such as insignificant alterations and minimum deterioration in the product. Drying is a traditional method of preserving fish being they have been used for centuries and dried salted products are popular in many areas, particularly in Africa, SE Asia and Latin America. In Bangladesh, About 20% of the artesian catch is sun dried and consumed in the domestic market [4]. Bangladesh earns a significant amount of foreign currency by exporting dried fish and fishery products which ranks third in the export item.

Now a day, the physical and organoleptic qualities of most of the sun-dried products available in the market are not satisfactory for human consumption. There are frequent complaints from the consumers about the quality of the products. To avoid this, in this research we use salt as a preservative before sun-drying. Sodium chloride has traditionally been used in curing and preservation of meat and fish due to its capacity to improve the water holding capacity of proteins. Brining reduces the microorganisms count on dry fish [5]. If the moisture content of fresh fish is reduced during drying to around 25%, bacteria cannot grow and autolytic activity will be greatly reduced, but to prevent mould growth, the moisture content must be reduced to 15% or lower. The presence of salt in the muscle tissue

In addition, it aids the removal of water by osmosis. When salt is added to fish before drying, final moisture content of 35% in the flesh, depending on the salt concentration may be sufficiently low to inhibit bacteria^[7]. Sodium chloride diffuses to the outside from muscles due to difference in osmotic pressure between the salt and fish muscle. This process does not continue indefinitely: sodium and chlorine ions form a water binding complex with protein which itself exerts an osmotic pressure and eventually equilibrium is reached^[8].

Channa striatus and *Channa punctatus* are popular air-breathing fresh water snake head fishes belongs to Channidae family and have long been regarded as valuable fish in Far East. In Bangladesh, *C. striatus* is known as “Shoal” and *C. punctatus* is known as “Taki”. These fish species are available in the fresh water stream in South Asia. Fish lipids are the main sources of polyunsaturated fatty acids (PUFAs)^[9]. These fishes’ *C. striatus* and *C. punctatus* contain polyunsaturated fatty acids (PUFA), which play important roles in cardiovascular system to reduce the risk of heart attack. Moderate fatty fish like- Shoal and Taki are suitable for sun-drying and dried taki fish is very popular food item among the local people of Bangladesh.

In the traditional storage of dried fish in Bangladesh, no proper measures are normally taken to protect the fish against unfavorable environmental conditions. Therefore, alternative affordable, safe, hygienic and environmental friendly methods must be developed and adopted for fish drying.

Considerable information are available about the nutritional aspects of different types of sun-dried product available in the market but very little is known about their quality whether this products are able to satisfy the consumer or not. The objective of this study was to find a suitable process for the drying environment for preserving fish by adding salt as preservative and to verify the curing method, quality changes during shelf life study and consumer acceptance of salt treated dried Shoal and taki fish products.

2. Materials and Methods

2.1. Collection of the fishes and location of the experiment

Fresh experimental fishes, shoal (*Channa striatus*) and Taki (*Channa punctatus*) had been collected from the river Meghna in the early hours of the day and the fishes were brought to the Fish Technology Section, IFST, BCSIR, Dhaka, Bangladesh for conducting the research activities, starts in the month of October, 2013. The whole experimental period covered 9 months of duration started from October, 2013 to June, 2014.

2.2. Preparation of fish

Fishes were carefully washed with cooled tap water. Head, scales, fins, gills and viscera were removed and again washed with tap water to remove blood, slime and unnecessary flesh. Due to the presence of hard shield like bony elements, bones of head are discarded as the waste.

2.3. Fresh Sample

A fresh flesh sample of Shoal and Taki fish species was taken to the laboratory for quality analysis of fresh experimental fish. About 6 or 7 slices was taken randomly which represented the parts from whole body of the fish. Then the slices were chopped with skin and finally ground with an electric blender to make a homogenous sample before being sampled for analysis.

2.4. Method of Sun-dried salting

Being a safe, antimicrobial and incidental food additive, toxic for some microorganisms, depressor of water activity (a_w) of the food, sodium chloride has been used as a seasoning and flavor enhancer as well as a preservative or curing agent^[10, 11, 12].

During this experiment the raw fishes were enrolled by dry commercial salt (NaCl) of about 30% by weight of the dressed fish (fish weight: salt weight 3:1). They were kept on a plastic bade basket in the sun. They were kept in sun regularly during day time (12 a.m. to 3 p.m.) for 7 days as sometimes the sky was cloudy and until the ripening period was over. At the same time, temperature and relative humidity were also recorded. During sun-drying, they were kept covered by dense meshed nylon or mosquito net to avoid outside contamination and prevent bird attack and fly infestation.

During sun-dried salting process, moisture content decreased and salt content increased considerably during the first 7 days which is called ripening period. The ripening of the product was determined by observing the changes in sensory characteristics such as color, texture, flavor etc. and changes in moisture content and salt penetration rate.

2.5. Storage of the product

At the end of drying period (ripening), sun-dried salted product of two fishes was packaging with plastic bag maintaining aseptic condition as far as possible and was stored at room temperature (27-30°C). The preservation period of product is linked to the amount of salt added; therefore a straight proportion is present between the amount of salt used and the preservation period^[13].

2.6. Sampling procedures

Evaluation of physical and chemical changes in sun-dried-salted Shoal and Taki fishes were carried out 1 month interval for the room temperature (26 °C-30 °C) until the fish become spoil or inedible condition. The experiment was done for second time at regular intervals during storage period. Salt crystal was removed from sun-dried salted fish-product using dry tissue paper before being sampled for analysis.

2.7. Quality analysis

Analytical methods were applied for the determination of chemical composition of the fresh fish and shelf-life quality of processed fish products on experimental basis. The analytical methods are given below:

- Sensory score evaluation has been done by using 9-point hedonic scales as described by Peryan and Pilgrim (9. Like extremely; 8. Like very much; 7. Like moderately; 6. Like slightly ;< 5. Bad)^[14].
- TVB-N was determined by Conway modified micro-diffusion technique^[15].
- pH was used to measure quality deterioration of Shoal and Taki fish using a pH meter (Mettler Toledo 320-s, Shanghi, China)^[16].
- FFA of the fish was determined by AOAC method^[17].

Data were analysed using SPSS for windows-20 statistical programme. Significance was established at $p < 0.05$.

3. Results & Discussion

TVB-N, pH value, FFA (Quality parameters) of fresh Shoal and Taki fishes were 4.41 mgN/100g, 6.9 and 0.6% and 3.43mgN/100g, 7.0 and 0.5% respectively (**Figure 1**).

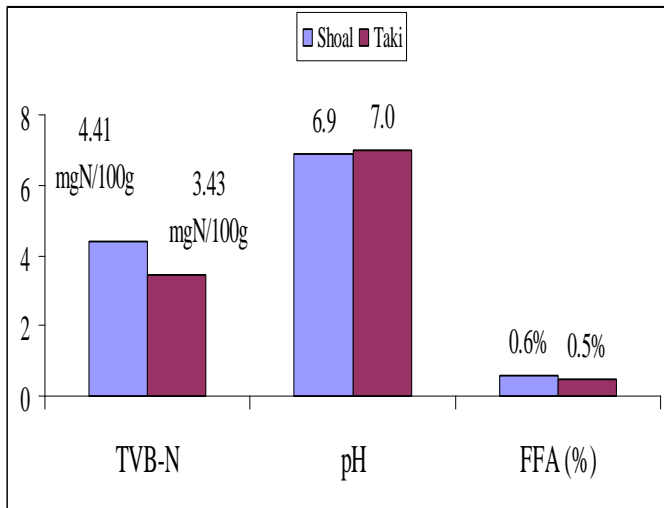


Fig 1: Initial quality of the fresh experimental fishes, Shoal (*Channa striatus*) and Taki (*Channa punctatus*).

3.1. Ripening period: Salting process starts when the surface of fish goes in contact with salt and is completed when all the fish reach the appropriate salinity, taste, consistency and odor.

Many workers agree that maximum salt uptake takes place within 6-7 days of salting without further uptake during subsequent storage [18, 19, 20]. Similar results also obtained in the present study where the fish contained maximum salt content in 7 days of salting. Decrease in moisture content have found during salting, which is due to the fact that the osmotic migration of salt into and water out of the fish [8, 21]. This led to increase in salt content and consequently extend shelf life of the products [22, 23]. During salting process, the changes in physico-chemical characteristics takes place and in certain stage the original characteristics of the raw fishes is found virtually absent. This stage is regarded as salt ripening of fish. According to Voskresensky these changes are induced by enzyme which breakdown both proteins and fats [24]. Borgstrom reported that salt ripening is the autolytic phenomena caused by the enzyme of the muscle or gastrointestinal tract [25]. During ripening changes induced by enzyme led to breakdown of proteins in tissue structures of muscle and the body organs of the fish. As a result some of the nitrogenous substances chiefly of low molecular weight diffuse from the fish into the salt brine. In present study, a comparatively higher salt content was observed in SDS Taki than SDS Shoal in 7th day (**Table 1**).

Table 1. Changes in salt penetration rate and its effect on moisture content in experimental fishes Shoal (*Channa striatus*) and Taki (*Channa punctatus*) during 7 days of ripening period

Days of ripening period	SDS Shoal		SDS Taki	
	Moisture (%)	Salt (%)	Moisture (%)	Salt (%)
0*	77.03	0	78.65	0
1	57.31	6.9	56.08	6.8
2	39.09	9.7	43.84	10.22
3	35.87	10.1	38.07	11.30
4	33.12	11.3	31.42	12.57
5	32.55	12.8	26.57	13.25
6	30.48	13.2	19.05	14.16
7	29.77	14.5	9.77	14.72

3.2. Sensory evaluation and score

During present study, high quality sun-dried salted fish products with excellent sensory and physical properties were obtained through this salting process. Now it is of interest to see how long these salted-dried products could be kept in acceptable condition during storage at room temperature. There were significant change in color, flavor, taste and texture in two fish species subjected to Sun-dried-salting methods. The table shows that with the lapse of storage time both products produce a salty taste with different degree of smell, color and texture. The changes of color from whitish to brownish may be due to lipid oxidation during storage period. This is quite clear from the present study that lipid oxidation presence of oxygen was more prominent than that of products stored in room temperature. In the present study there was no fungal attack in sun-dried salted Shoal and Taki fish products. According to the panel's evaluation, the sensory properties of

sun-dried salted (SDS) Shoal and Taki fish-products were in acceptable condition throughout storage period though, statistically there was significant difference ($p < 0.05$) in the sensory evaluation during storage period based on the panel's score. The initial score of the sensory evaluation of SDS Shoal and Taki was 9. But during storage period this score rapidly decreased and at the end of the storage period, the score was 5 in case of SDS Shoal (5 month) and SDS Taki (8 month). Yu applied this hedonic rating scale to evaluate the acceptability of sun dried fishes by their external morphological and quality changes [26]. Morshed applied the hedonic rating scale by using 9-points for the sensory evaluation of the dried and dehydrated fish [27].

The sensory analysis of salted- sun dried (SDS) Shoal and Taki fishes were done and reported that the quality of salted sun- dried Taki fish-product was much better (**Table 2**).

Table 2: Sensory evaluation of Sun-dried salted Shoal and Taki fish-products during different days of observation at room temperature

Observation period	Product	Flavor(Smell / Odor)	Color	Texture	Comment /Remarks	Hedonic scale score (0-9)
0 Day	Shoal	Attractive salty odor	Whitish	Tough	Excellent	9
	Taki	Attractive salty odor	Whitish	Comparatively Tougher & shrunken	Excellent	9
1 month	Shoal	Attractive salty and slightly fishy odor	Whitish	Comparatively Tougher& shrunken	Excellent	8.6
	Taki	Stimulating salty & fishy odor dominant	Whitish	Comparatively Tougher & shrunken	Excellent	8.7
2 month	Shoal	Attractive salty and fishy odor dominant	Whitish	Comparatively Tougher& shrunken	Excellent	8.5
	Taki	Flavorful salty & fishy odor	Whitish	Firm	Very good	8.6
3 month	Shoal	Slightly salty & characteristic fishy odor	Fade brown	Semi-Elastic	Very much good	8.0
	Taki	Characteristic fishy odor	Whitish	Firm	Good	8.5
4 month	Shoal	Slightly salty odor present	Yellowish brown	Elastic	Slightly Good	7.5
	Taki	Characteristic fishy odor dominant	Whitish	Firm	Moderately good	8.0
5 month	Shoal	Slightly fishy odor present	Yellowish brown	Slightly soft	Neither like or dislike	5
	Taki	Distinctive fishy & slightly salty odor	Whitish	Firm	Slightly good	7.5
6 month	Shoal	Faded odor	Faded radish	Comparatively soft.	Rejected	4.5
	Taki	Fishy odor dominant	Whitish	Nearly firm	Slightly accepted	6.5
7 month	Shoal	*	*	*	*	*
	Taki	Salty odor absent	Whitish	Nearly firm	Just accepted	6
8 month	Shoal	*	*	*	*	*
	Taki	Slightly faded fishy odor	Fade	Comparatively soft	Neither like or dislike	5
9 month	Shoal	*	*	*	*	*
	Taki	Slightly Rancid odor	Fade	Comparatively soft	Rejected	4.5

*= Rejected due to sensory evaluation

3.3. Changes in Total Volatile base Nitrogen (TVB-N) value: Total volatile base nitrogen (TVB-N) is important compound provide a measure of the progress of spoilage that is independent of sensory assessment. Wallace has pointed out that TVB-N is better index of spoilage [28]. The result obtained for TVB-N is presented in **figure-2**.

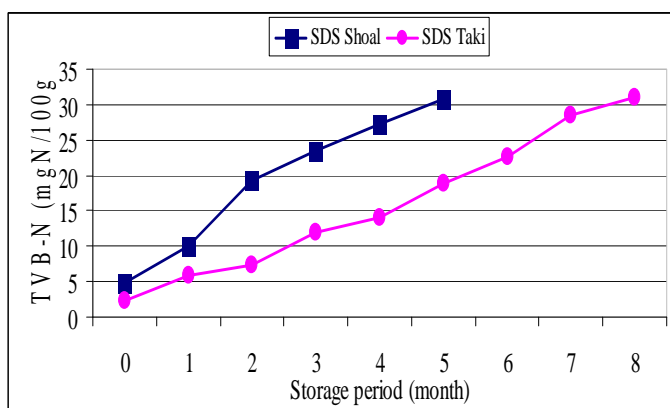


Fig 2: Changes in TVB-N (mgN/100g) contents of sun-dried salted (SDS) Shoal and Taki fish during different duration of storage at room temperature.

TVB-N values were found to vary from 4.89 (o day) to 30.86 mg N/100g (5 month) for SDS Shoal and 2.27 (o day) to 31.02 mg N/100g (8 month) for SDS Taki. TVB-N values of the products storage at room temperature showed linearly increasing pattern throughout storage period but neither of the value exceeded the recommended value set for fish regarded as acceptable condition. The limiting level for rejection of TVB-N is 30-40mgN/100g for storage at ambient temperature [29]. The present findings are in close association with him. The rate of spoilage increases with the time and is closely interrelated. The same result had been evident from other researchers [30, 31]. The stage perhaps due to autolysis in the tissue [32].

3.4. Changes in pH value: pH is an indicator of the extent of microbial spoilage in fish and some proteolytic microbes produce acid after decomposition of carbohydrate, thereby increasing the acid level of the medium [33]. The pH value is a reliable indicator of the degree of freshness or spoilage. The pH in fresh condition freshwater fish flesh is almost neutral [34]. In the post-mortem period, decomposition of nitrogenous compounds leads to an increase in pH in the fish flesh [35]. The increase in pH indicates the loss of quality. Although, it was stated that a measurement of pH is unreliable for most species

of fish because the end products of spoilage of both alkaline and acidic nature tend to neutralize each other [36]. Most microorganisms grow the best at pH values between 6.6 and 7.5, whereas only a few grow at a pH below 4.

pH value of fresh Shoal and Taki fish were found 6.9 and 7.0 respectively in the present study. But when salt was added with fish, pH value decreases rapidly 6.2 for SDS Shoal and 5.9 for SDS Taki. This result is higher than that reported by Riebroy, who found that the pH in Thai-fermented fish mince for fresh fish is 6.3, while fermented is 4.6 [37]. This result is in the normal ranges reported by other researchers [38, 39, 40]. After that the pH value of SDS shoal and taki fish-product was increased significantly ($P < 0.05$) with storage period at room temperature. In the present study pH value were found to vary from 6.2 (0 day) to 8.3 (5 month) for SDS Shoal and 5.9 (0 day) to 7.9 (8 month) for SDS Taki (Figure 3).

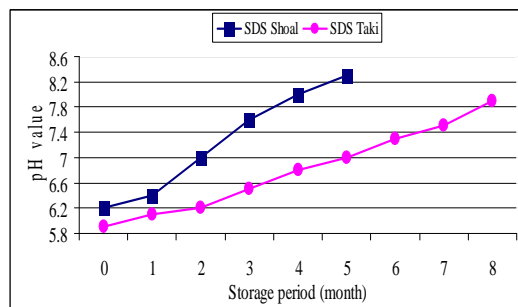


Fig 3: Changes in pH value of sun-dried salted (SDS) Shoal and Taki fish during different duration of storage at room temperature.

3.5. Changes in FFA (Free Fatty Acid) value: The FFA value which indicates the rancidity of fat of 2 types of sun-dried salted fishes during storage at room temperature was shown in Figure 4.

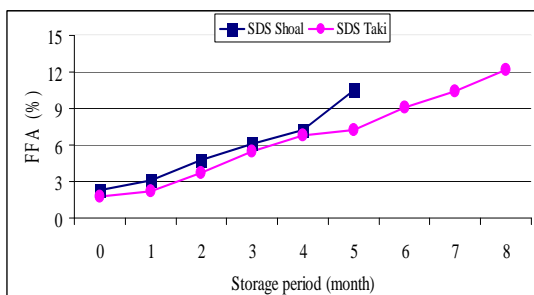


Fig 4: Changes in FFA (%) value of sun-dried salted (SDS) Shoal and Taki fish during different duration of storage at room temperature.

The FFA value of sun-dried salted shoal and taki fish increased gradually with the passing of storage period. FFA value is a measure of the extent of oxidative deterioration in oily fish, but it can fall further at latter stages of fish spoilage [41]. A high level of FFA is characteristics of product that have undergone both microbial and biochemical spoilage [8, 42]. This may indicate that greater proportions of unsaturated fatty acids were liberated and were subjected to oxidative splitting at the double bonds. The resulting substances, mostly ketones and aldehydes, appear to be largely responsible for flavor, odor and taste of the salted fish product [43]. The same result was found in the present study.

In the present study FFA values were found to vary from 2.3% (0 day) to 10.5% (5 month) for SDS Shoal and 1.8 % (0 day) to 12.2% (8 month) for SDS Taki respectively. After 6 and 24 months of storage (at -13°C to -25°C) the appearance of considerable contents of FFA with certain bad odors and off flavors presumably derived from the degradation of fats, greatly reduced the consumer appeal of trout [44]. The present finding is closely related with that of Rahman who reported the FFA value was 1.16% for raw hilsa fish and after 8 weeks of observation, the FFA value of dry salted hilsa products at room temperature ($26 - 30^{\circ}\text{C}$) reached to 11.7% [45]. Free fatty acid (FFA) value ranged from 2.9% of total lipid on the start day to 7.58, 7.15 and 8.56% on the 60 days of observation in dry salting, wet salting and sundry salted fishes respectively [46]. While the initial value of raw pre-spawning and post-spawning hilsa was 1.15% and 1.21% respectively which after dry salting increased to 7.86% and 8.35% respectively on 18th days of storage at 28°C to 32°C [47]. Free fatty acid contents increased from 4.55-5.12% within 4 days of drying and then gradually increased up to 10 days of drying (6.86%) [48]. The present study denoted that the contents of free fatty acid values are similar with the above mentioned studies. The FFA value increased in a characteristics pattern to a certain level of storage period.

4. Conclusion

The present investigation revealed that, processing and storage significantly affected the quality of fish-products. The application of salt was much more effective in drying method and subsequent uses of salt are required to keep fish-products longer from deterioration. The results of chemical analysis and sensory evaluation carried out, proves that the overall shelf-life quality of sun-dried Taki fish product is best. Commercial traders those who produce market dry-fish in our country may be asked to follow the suggestions made over here on the basis of the findings of the present study.

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