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Effect of salt concentration on the quality aspects of sun-dried ribbon fish (*Trichiurus lepturus)*

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Abstract. A study was conducted to investigate the changes in organoleptic properties, biochemical composition and microbial load of fresh, control dried (T1: treated with no salt), 15% (T2) and 25% salt (T3) dried ribbon fish (*Trichiurus lepturus*) stored within polyethene bag at ambient (28-33°C) and refrigeration temperature (4°C) and to observe the effects of salt on the shelf life and overall quality of the dried ribbon fish during 2 months of storage period. The60 days study showed no significant changes in mean general acceptability of dried fish stored at both temperatures. The initial moisture, crude protein, lipid and ash content of T1, T2 and T3 dried fish were 14.40, 62.74, 9.05 and 13.65%; 20.03, 55.15, 7.40 and 16.96%; and 22.80, 51.60, 7.22 and 18.30%, respectively. The changes in the proximate composition of dried fish at both storage temperatures were not noticeable during storage period. The initial TVB-N and SPC value forT1, T2 and T3 dried fish were 6.38, 5.96, 5.45 mg/100g, and 9.81×10^4, 9.30×10^4, 8.80×10^4 CFU/g, respectively. After 2 months of storage these values increased slowly for the products stored at ambient temperature and in case of refrigeration temperature the changes were not significant. The salt dried fish were organoleptically better than the unsalted products. Between two brine concentrations,15% salt dried fish was found to be of better quality in terms of oraganoleptic properties and proximate composition whereas 25% salt dried fish was better in terms of TVB-N content and microbiological aspects.

Keywords: Ribbon fish, Sundried fish, Quality aspects, Organoleptic properties

Introduction

Fish drying in Bangladesh is the common and profitable business. Dry fish is one of the popular food items in Bangladesh. It is an important source of protein in our country. It is relished by many people of coastal, central and North-eastern districts of the country. Salt dried fish is an important source of animal protein available at comparatively cheaper price for the economically weaker sections of the society, especially people residing in coastal areas (Prasad *et al*. 1999). During open sun drying fish gets heavily contaminated. The physical and organoleptic qualities of many traditional sun dried products are not satisfactory for human consumption (Reza *et al*. 2005, Hasan 2006). Insect infestations caused by fly (*Diptera*) and beetle are the real problems in dried fish in Bangladesh (Nowsad 2007). In tropical climates, under humid conditions, heavy infestation of unsalted dried fish by blow flies may cause up to 30% loss of the product (Wood 1981). Other problems markedly evident with dried fish are the contamination during different stages of handling and processing and the indiscriminate use in the form of dip and spray of various types of pesticides. Dried fish contaminated with both insects and insecticides comprises about 60% of the total dried products that is considered to be unfit for human consumption (Nowsad 2005). Salt protects the raw fish against spoilage and kills the eggs and larvae of insects and thus reduces insect infestation. If a pretreatment of salt is done in the fish during sun drying, it will make the texture compact, reduce the effect of contamination, destroy some of the bacteria and help release water from the fish so that drying becomes easier and quicker (Nowsad 2007). The presence of the pathogenic loads in dried fishes is acquiring importance in view of the safety and quality of the seafood (Patterson and Ranjitha 2009). In this study, the most popular species, Ribbon fish (*Trichiurus lepturus*) was used for drying using different salt concentration as the salt shows insect repellant with bactericidal effect.

Materials and Methods

Fresh ribbon fish were collected from fish landing yard of Cox's Bazar, and transported to the Laboratory of Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, using an insulated box with ice (1:1). The facilities required for the experiment were developed and installed in the laboratory premises. Sun drying of the fish was done using a ring tunnel dryer. The experiment was conducted from July to September, 2017.

***Sorting* and s*alt treatment*:** The experimental fish were sorted according to general appearance and damaged portion and dressed by gutting and evisceration followed by washing and weighing. Three treatments were considered for experimental purpose. These were control dried: (T1: Fish treated with no salt), T2: 15% salt dried (treated with 15% salt solution (NaCl)) and T3: 25% salt dried (treated with 25% salt solution. The two salt solutions were prepared separately in two clean buckets using potable water and fishes were dipped for 15 minutes in both treatments.

***Dewatering and drying*:** After removing from brine solution fishes were kept on two plastic trays and air dried in room temperature for about 10 minutes. The fishes in different treatments were dried in the sunlight using a ring tunnel dryer. The tunnel was covered by mosquito net. Sun drying was continued until the moisture content of the fish was found to be less than15-18%.

Grading and packaging: The dried fish were graded according to size, broken products/parts or any other abnormalities. The products were packed separately in polyethylene bag to avoid any infestation by beetles and mites. The bags were sealed by using an electrical sealing machine.

Storage of the dried fish products: The dried products were divided into two portions. One portion was kept at ambient temperature (28-33ºC) and other portion was stored at refrigeration temperature (4ºC).

Organoleptic Quality Assessment: Sensory evaluation was done at 15 days interval for the dried fish stored at ambient and refrigeration temperature. A 9-point hedonic scale was used to evaluate the changes in color, flavor/odor, texture, taste, insect infestation, broken pieces and general appearance until it was safe to eat and acceptable in accordance with the Larmond (1977)method.

Proximate composition analysis: Proximate composition analysis namely moisture, crude protein, lipid and ash was carried out according to AOAC (2000). Proximate analysis of control dried and salt-dried fish were done on 1st, 15th, 30th, 45th and 60th day of preservation at ambient temperature and refrigeration temperature.

Determination of Total Volatile Base Nitrogen (TVB-N): The TVB-N value was calculated by using the following formula:-

$$\text{TVB-N (mg/100g sample)} = \frac{\text{ml of titrant used} \times 0.014 \times \text{Normality of titrant}}{\text{Weight of sample (g)}} \times 100$$

Total Bacterial Count of the Control dried and Salt-dried Ribbon Fish: Standard Plate Count (SPC) was used for total plate count of the dried ribbon fish. Bacterial load (CFU/g) was calculated using the following formula:

$$\text{CFU/g} = \frac{\text{Average no. of colonies in petridishes} \times 10 \times \text{dilution factor} \times \text{wt. of total sample solution}}{\text{Wt. of fish sample (g)}}$$

Result and Discussion

Sensory evaluation: Organoleptic characteristics including color, odor, texture, flavor, taste, presence of broken parts and overall quality of T1, T2 and T3 stored at ambient temperature (AT) and refrigeration temperature (RT) were observed on a nine point scale (Larmond 1977) in which 9.0 was considered the best and 1.0 was considered the worst. These properties were observed during 2 months of the storage period. T2 dried fish was found to have good and attractive appearance with whitish brown color and slightly less firm and flexible texture than that of control dried fish (T1). T3 dried fish was observed to have almost same color and appearance like T2 fish but the texture was less firm and flexible than that of T2 fish. All three products showed excellent and attractive appearance up to 60^{th} day. On the 60^{th} day control dried fish showed almost similar firm and flexible texture as it was seen on the 1^{st} day of storage where T2 fish showed comparatively slightly less firm and flexible texture than that of 1^{st} day of storage. T3 fish showed less firm and flexible texture than that of T2 fish. Color of T2 and T3 fish was less white brownish after 60 days of storage but it was preferred by the panelists. The initial mean acceptability score of control dried, T2 and 25% T3 fish was in the range of 8.81 to 8.84 with higher value in T2 fish followed by T3 fish and then T1 fish.

The mean acceptability score after two-month storage in ambient condition was in the range of 7.65 to 7.72 with maximum value found in T2 and minimum value was obtained from T1 fish (Table I). In case of products stored at refrigeration temperature the mean general acceptability score ranged from 8.03 to 8.84 with highest value found in T2 fish and lowest value from T1 fish (Table I).Sensory quality of salt dried products was better than control dried products. Brine concentration plays an important role in texture development, influences inter and intra molecular bonds of the muscle protein bringing about change in structure, denaturation of proteins and water holding capacity of the muscle (Thorarinsdottir *et al.* 2002). Salt softens the texture and improves the flavor of dried fish products (Nowsad 2007).

Table I. General mean acceptability scores (according to Larmond 1977) for the dried fish stored at ambient temperature (AT: 28-33^{0}C) and refrigeration temperature (RT: 4^{0}C). **CD= Control dried, 15%= 15% salt dried, 25%= 25% salt dried. **Excellent and attractive: ≥ 7 to ≤ 9, Acceptable: ≥ 5 to below 7, just satisfactory: ≥ 3 to below 4, Rejected: ≤ 3.

Storage period (day)	Treat-ment	Sensory parameters											
		Color		Flavor		Texture		General appearance		Taste		General acceptability	
		RF	AM	RF	AM	RF	AM	RF	AM	RF	AM	RF	AM
1st	CD	8.90	8.90	8.85	8.85	8.84	8.84	8.78	8.78	8.70	8.70	8.81±0.08	8.81±0.08
	15%	8.92	8.92	8.88	8.88	8.88	8.88	8.80	.80	8.74	8.74	8.84±0.07	8.84±0.07
	25%	8.91	8.91	8.83	8.83	8.86	8.86	8.82	.82	8.68	8.68	8.82±0.09	8.82±0.09
15th	CD	8.85	8.6	8.75	8.68	8.70	8.62	8.78	8.70	8.59	8.52	8.73±0.10	8.62±0.07
	15%	8.88	8.58	8.78	8.70	8.85	8.78	8.81	8.78	8.65	8.57	8.79±0.09	8.68±0.10
	25%	8.87	8.52	8.70	8.62	8.82	8.72	8.80	8.76	8.61	8.50	8.76±0.10	8.62±0.12
30th	CD	8.65	8.4	8.50	8.20	8.62	8.45	8.69	8.45	8.29	8.16	8.55±0.16	8.33±0.14
	15%	8.64	8.43	8.60	8.43	8.79	8.50	8.75	8.53	8.35	8.28	8.63±0.17	8.43±0.10
	25%	8.60	8.38	8.55	8.45	8.76	8.46	8.73	8.48	8.32	8.20	8.59±0.18	8.39±0.11
45th	CD	8.42	8.00	8.20	7.75	8.48	8.38	8.45	8.20	7.90	7.80	8.29±0.24	8.03±0.27
	15%	8.40	7.98	8.27	7.95	8.55	8.32	8.56	8.34	8.10	7.90	8.38±0.20	8.10±0.21
	25%	8.35	7.86	8.32	7.98	8.51	8.24	8.52	8.28	7.94	7.86	8.33±0.24	8.04±0.20
60th	CD	7.98	7.75	7.89	7.30	8.32	7.90	8.22	7.60	7.75	7.68	8.03±0.23	7.65±0.22
	15%	7.95	7.68	7.97	7.50	8.45	7.85	8.36	7.79	7.82	7.77	8.11±0.28	7.72±0.14
	25%	7.93	7.65	7.94	7.56	8.40	7.82	8.33	7.70	7.79	7.72	8.08±0.27	7.69±0.01

Proximate composition

Moisture content: The moisture content of T1, T2 and T3 dried fish was 14.40, 20.03 and 22.80% respectively. The moisture content of the T1, T2 and T3dried fish kept at ambient temperature increased very slowly from initial to 16.62, 22.23 and 24.22% respectively at 60 days of storage (Fig. 1). In case of products kept at refrigeration temperature, the moisture content of T1, T2 and T3 dried fish increased to 16.35, 21.4 and 23.72%, respectively (Fig. 1). Moisture content increased in very small amount during the storage period to absorption of moisture from surrounding atmosphere. Increase in moisture content could be attributed to the difference in the moisture of the processed fish relative to the surroundings (Daramola *et al.* 2007). Akter (2009) observed, moisture content of salt-dried and salt and turmeric treated sun-dried kachki (*Corica soborna*) gradually increased through entire period of storage both at room and refrigerator temperature which is in harmony with present findings. In both storage conditions T2 and T3 dried products absorbed more moisture than T1 dried products. It may be explained by the fact that salt is hygroscopic in nature. During salting sodium and chloride ions form a water binding complex with fish protein (Nowsad 2007). So, absorbed salt particles inside the fish muscle tissue hold some water molecules. Imtiaz *et al.* (2017) reported that moisture content of unsalted and salt dried ribbon fish was 17.37 and 24.78% respectively. Nooralabettu (2008) reported that salted dried fish with moisture content < 25% can have an extended shelf life of up to several months.

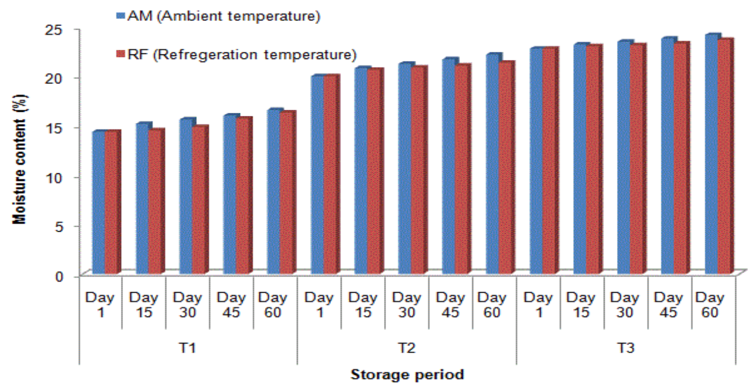

Figure 1: Changes in Moisture content (%) of ribbon fish with different treatments stored at ambient (28-33^{0}C) and refrigeration (4^{0}C) temperature

Protein content: The protein content of dried products stored at ambient temperature fall from 62.74 to 61.77% for T1, 55.15 to 54.32% for T2, and 51.6 to 50.97% for T3 fish after 2 months of storage period (Fig. 2). The protein contents for the T1, T2 and T3 dried products stored at refrigeration temperature were 61.92, 54.77 and 51.45% respectively after 60 days of storage (Fig. 2). Protein content of salt dried fish was lower than that of control dried fish. It may be explained by the fact that the proteins are denatured during salting, and these result in loss of salt soluble proteins, especially high molecular weight proteins. Sannaveerappa *et al.* (2004) observed that salting reduced the amino acids, non-protein nitrogen and sulphydryl groups in salted milkfish. Farid *et al.* (2016) stated that the protein (%) content of freshly processed turmeric and 30% salt treated sun-dried taki and tengra fish-products was 46.06 and 42.60%. Siddique *et al.* (2011) observed that the protein level of three marine dried fishes (*Harpadon nehereus, Johnius dussumieri* and *Lepturacanthus savala*) was varied from 58.33-51.98%, 64.39-56.46% and 71.90-67.22% respectively during changes of storage period which supports decreasing trend of protein content of dried ribbon fish during storage period.

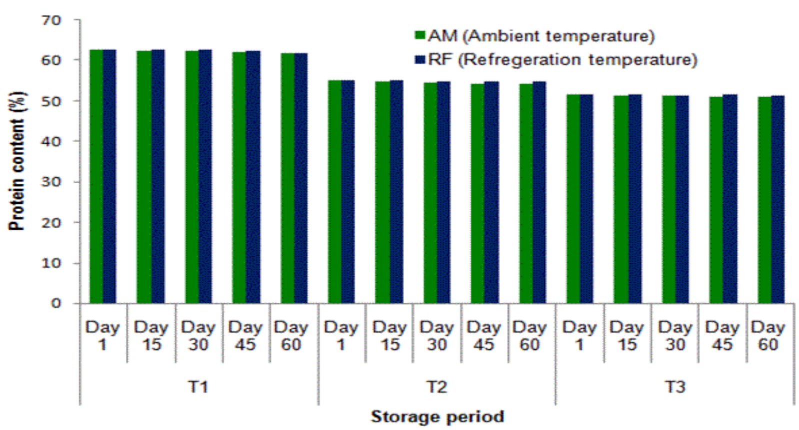

Figure 2: Changes in Protein content (%) of ribbon fish with different treatments stored at ambient (28-33^{0}C) and refrigeration (4^{0}C) temperature

Ash content: The ash content of T1, T2 and T3 fish was 13.65, 16.96 and 18.3% respectively at 1st day of storage. In case of products stored at ambient temperature (28-33°C) the ash content of T1, T2 and T3 fish was 12.35, 16.24 and 17.38% respectively after 60 days of storage (Fig. 3). On the other hand, ash content of the products kept at refrigeration temperature (4°C) was 12.82% for control dried fish, 16.42% for 15% salt treated dried fish and 17.55% for 25% salt treated dried fish respectively after 2 months of storage period (Fig. 3).The ash content of the products was found highly increased after drying due to removal of major portion of the moisture inside the fish tissue. The higher values of total ash content in salted sun-dried fish-products were attributed to high salt content which added more ash components to the products. These results were in accordance with El-Bassir *et al.* (2015). Pravakar *et al.* (2013) reported that the ash content of sun dried Chinese pomfret and Ribbon fishes were ranged from 7.02 to 7.38 % and 10.29 to 11.64 % whereas the ash content of Bombay duck was 19.64 to 20.31%.

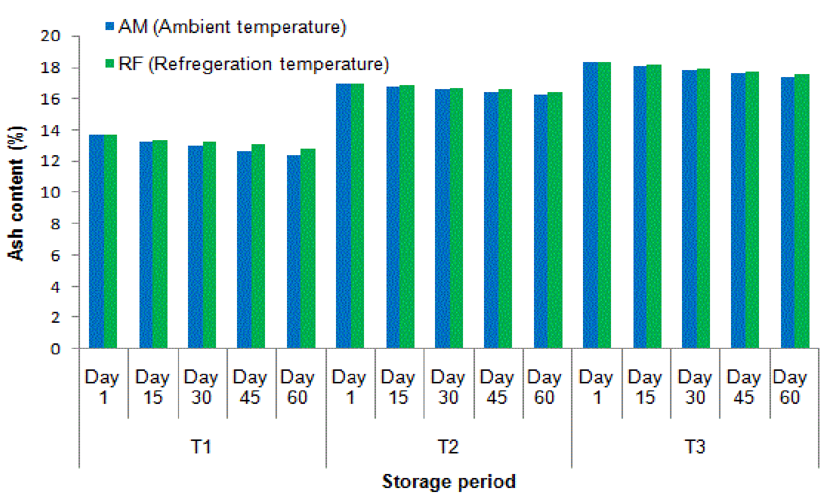

Figure 3: Changes in Ash content (%) of ribbon fish with different treatments stored at ambient (28-33^{0}C) and refrigeration (4^{0}C) temperature

Lipid content: Initially the lipid content of T1, T2 and T3 dried ribbon fish was 9.05, 7.40 and 7.22% respectively in fresh processed condition. The lipid content of the products kept at ambient temperature decreased to 8.35% for T1, 6.55% for T2, and 6.51% for T3 dried fish after 2 months of storage (Fig. 4). On the other hand, at refrigeration temperature, the lipid content of T1, T2 and T3 dried ribbon fish was 8.45, 6.80 and 6.53% respectively after 60 days of storage period (Fig. 4). During the storage period, the lipid content of dried fish stored both at ambient and refrigeration temperature was observed to have very slow decreasing trend, might be due to the inverse relationship between moisture and fat content. Lipid (7.0-21.0%) content of the salt dried fish was high compared to the fresh equivalent (lipid 1.0 ± 0.18%).

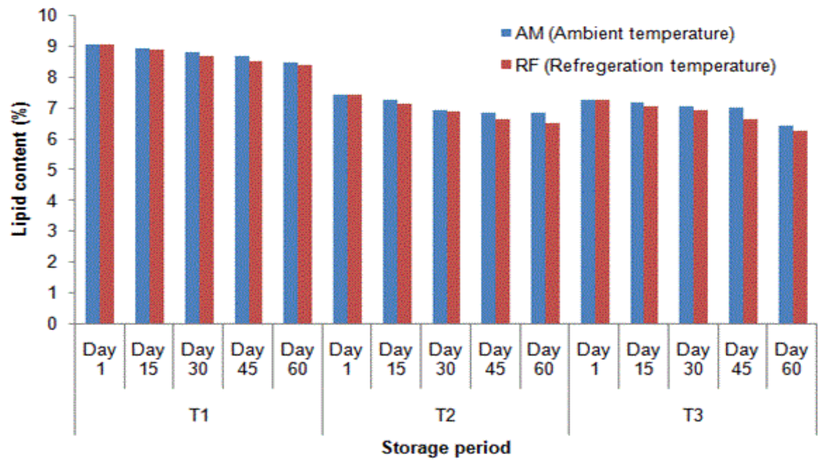

Figure 4: Changes in Lipid content (%) of ribbon fish with different treatments stored at ambient (28-33^{0}C) and refrigeration (4^{0}C) temperature

This increase was due to the salting and drying process where moisture was removed and dehydration occurs, resulting in a concentration of other nutrients such as protein and lipid (Chukwu and Mohammed 2009, Hwang *et al*. 2012). Pravakar *et al*. (2013)reported the lipid content of Chinese pomfret was 11.60 to 12.25 % and ribbon fish ranged from 11.33 to 11.63 whereas the Bombay duck had 10.22 to 10.61%. Siddique *et al.* (2011) observed that the lipid level of three marine dried fishes (*Harpadon nehereus, Johnius dussumieri* and *Lepturacanthus savala*) varied from 7.78-5.86%, 5.54-4.87% and 7.79-6.66% respectively during changes of storage period.

TVBN content: After drying TVB-N content of the fish increased in the products and it further increased slowly with the increment of storage time. In fresh processed condition the TVB-N content of T1, T2 and T3 dried ribbon fish was 6.38, 5.96 and 5.45 mg/100g respectively. The TVB-N content of dried fish stored at ambient temperature was found to vary from 6.38 to 23.95 mg/100g for T1, 5.96 to 19.39 mg/100g for T2 and 5.45 to 17.87 mg/100g for T3 fish after 2 months of storage (Table II). On the other hand TVB-N content of the products stored at refrigeration temperature showed variation from 6.38 to 15.71 mg/100g for T1, 5.96 to 13.35 mg/100g for T2 and 5.45 to 12.82 mg/100g for T3 dried fish after 60 days of storage (Table II). The TVB-N values of all the samples were found to be lower than the recommended value (100-200 mg/100 g) for a variety of salted and dried products and the limiting level for rejection of TVB-N is 20 mg/100g for refrigeration temperature stored fish-products (Connell, 1995). Reza *et al*. (2008) observed that the total TVB-N content were 5.3 to 19.0 mg/100 g in traditionally sun dried ribbon fish. The upper limit of TVB-N is 30 mg/100 g, which certify the acceptable level for fin fish dried products (Connell 1995). TVB-N content of products in this experiment stored at refrigeration temperature was significantly lower than that of stored at ambient temperature due to reduced enzymatic action and retarded bacterial growth in the dried products at low temperature. Srikar *et al*. (1993) pointed out that storage at higher temperatures accelerates the rate of TVB-N production in dry, wet and mixed-salted fish. They also found that TVB-N values at ambient temperature-stored products were higher than that at the lower temperature (2.5 °C).

Table II: Total Volatile Base Nitrogen (TVB-N) of control dried (T1), 15% salt (T2) and 25% salt (T3) dried ribbon fish during storage at ambient (AT: 28^0-33^0C) and refrigeration temperature (RT: 4^0C)

Storage period (Day)	Product Name					
	T1 (AM)	T1 (RF)	T2 (AM)	T2 (RF)	T3 (AM)	T3 (RF)
1st	6.38±0.11	5.96±0.09	5.96±0.09	5.45±0.11	5.45 ±0.17	5.45±0.17
15th	13.22±0.06	7.29±0.17	9.05±0.15	6.97±0.19	8.33±0.05	6.88±0.05
30th	16.94±0.34	10.75±0.08	13.38±0.06	8.51±0.15	12.40±0.21	7.69±0.17
45th	20.96±0.12	14.69±0.19	17.06±0.40	10.68±0.13	15.95±0.36	10.51±0.11
60th	23.95±0.22	15.71±0.11	19.39±0.05	13.35±0.11	17.87±0.09	12.82±0.15

Microbial load: After drying, the bacterial load of T1, T2 and T3 dried ribbon fish was 9.81×10^4, 9.30×10^4 and 8.80×10^4 CFU/g respectively. On the 60th day of storage the Standard Plate Count (SPC) of dried fish stored at ambient temperature was 2.83×10^5 CFU/g for T1, 2.07×10^5 CFU/g T2 and 1.72×10^5 CFU/g for T3 dried fish (Table III). On the other hand, the dried fish stored at refrigeration temperature had the value of SPC as 1.81×10^5, 1.55×10^5 and 1.18×10^5 CFU/g for T1, T2 and T3 respectively after 60 days of storage (Table IV). Compared to ambient temperature, the growth of bacteria was slow in control dried products but the growth was slower in case salt dried products at refrigeration temperature. Increasing salt concentration reduced the growth of bacteria in the dried products. Lowest bacterial load was found in 25% salt dried ribbon fish due to combined effect of salting, drying and storage at low temperature (4°C). The addition of high salt concentrations reduces moisture and thus extends storage stability by preventing microbial spoilage (Guizani *et al*. 2008; Hwang *et al*. 2012). Pravakar *et al.*(2013) stated that the bacterial loads of the traditional dried products from Chinese pomfret (*Stromateus chinensis*), Bombay duck (*Harpadon nehereus*) and Ribbon fish (*Trichiurus lepturus*) were 3.8×10^5, 3×10^4 and 2.1×10^5 CFU/g respectively. Reza (2002) observed that the aerobic plate count of solar tunnel dried marine fishes (silver jew fish, Bombay duck, big-eye tuna, Chinese pomfretand ribbon fish) from 1 day ice stored samples were 1.8×10^3 to 2.6×10^4, 2.6×10^3 to 2.6×10^4, 5.4×10^4 to 6.0×10^5, 8×10^2 to 3×10^5 and 5×10^3 to 1×10^5 CFU/g respectively. 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). In this study, SPC of dried fish-products increased during refrigeration storage period which might be due to handling contamination but values of SPC were within the limits of 10^7 CFU/g specified for quality grading of fish by the International Commission of Microbiological Standards for Foods (1996).

Table III. Standard plate count (CFU/g) of fresh, T1, T2 and T3 fish stored at ambient temperature

Storage period (Day)	Fresh fish		T1 (Control dried)		T2 (15% salt dried)		T3 (25% salt dried)	
	CFU/g	Log CFU/g	CFU/g	Log CFU/g	CFU/g	Log CFU/g	CFU/g	Log CFU/g
1st	5.56×10^5	5.75	9.81×10^4	4.99	9.30×10^4	4.97	8.80×10^4	4.94
15th	-	-	1.07×10^5	5.03	9.87×10^4	4.99	9.42×10^4	4.97
30th	-	-	1.76×10^5	5.25	1.41×10^5	5.15	1.04×10^5	5.02
45th	-	-	2.52×10^5	5.40	1.85×10^5	5.26	1.35×10^5	5.13
60th	-	-	2.83×10^5	5.45	2.07×10^5	5.31	1.72×10^5	5.23

Table IV. Plate count of fresh, control dried, T1, T2 and T3 fish stored at refrigeration temperature

Storage period (Day)	Fresh fish		T1 (Control dried)		T2 (15% salt dried)		T3 (25% salt dried)	
	CFU/g	Log CFU/g	CFU/g	Log CFU/g	CFU/g	Log CFU/g	CFU/g	Log CFU/g
1st	5.56×10^5	5.75	9.81×10^4	4.99	9.30×10^4	4.97	8.80×10^4	4.94
15th	-	-	1×10^5	5.00	9.63×10^4	4.98	9.21×10^4	4.96
30th	-	-	1.24×10^5	5.09	9.89×10^4	4.99	9.73×10^4	4.99
45th	-	-	1.60×10^5	5.20	1.28×10^5	5.11	1.01×10^5	5.00
60th	-	-	1.81×10^5	5.26	1.55×10^5	5.20	1.18×10^5	5.07

From the experiment it has been found that the salt dried (T2 and T3) ribbon fish were organoleptically better than the unsalted products due to their comparatively soft texture, attractive color and slight salty taste. In terms of TVB-N content and microbiological aspects the salt dried products were quite better than that of the unsalted dried fish products which indicates that the salt dried fish can be kept in storage with higher microbial quality and can be stored longer than the unsalted dried fish. Between two brine concentrations 15% salt dried fish was found to be better in terms of oraganoleptic properties and proximate composition whereas 25% salt dried fish was better in terms of TVB-N content and microbiological aspects. Therefore, 15% salt dried fish is recommended as best revealed by this study.

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