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EFFECT OF SALT CONCENTRATION ON THE REHYDRATION CAPACITY OF SUNDRIED RIBBON FISH (*Trichiurus haumela*) STORED AT AMBIENT (28-33^{0}C) AND REFRIGERATION (4^{0}C) TEMPERATURE

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ABSTRACT

A study was done to investigate the changes in water rehydration capacity of laboratory prepared control dried (dried fish treated without salt), 15% salt dried and 25% salt dried ribbon fish (*Trichiurus haumela*) stored in polyethene bag at ambient (28-33^{0}C) and refrigeration temperature (4^{0}C). The main objective of this study was to observe the effect of salt on the rehydration capacity of the dried ribbon fish during 2 months storage period. On the 1st day of storage the reconstitution level of control dried, 15% salt and 25% salt dried fish at 28^0, 40^0 and 60^{0}C was in the range of 30.05 to 70.98% having maximum value for control dried fish after 60 minute of soaking at 60^{0}C and minimum value for 25% salt dried fish after 15 minute of soaking at 28^{0}C. The reconstitution capacity of the dried fish products gradually increased with increasing soaking time and temperature. After 60 days of storage the rehydration capacity of dried products at same temperatures of 28^0, 40^0 and 60^{0}C ranged between 27.16 to 61.43% with highest value for control dried products stored at refrigeration temperature (4^{0}C) after soaking for 60 minutes at 60^{0}C and lowest value for 25% salt dried fish stored at ambient temperature (28-33^{0}C) after soaking for 15 minutes at 28^{0}C. Rehydration capacity of the dried products decreased very slowly during storage period due to the slow increment of moisture in the products stored both at ambient and refrigeration temperature. Salt-dried fish absorbed less moisture than that of unsalted dried fish and increased salt concentration resulted in the lower moisture absorption in the dried fish and thus reduced rehydration capacity.

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INTRODUCTION

Salt dried fish is an important source of animal protein available at cheaper price for the economically weaker sections of the society, especially people residing in coastal areas (Prasad et al., 1999). 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). Drying of marine fish is very common in the entire coastal areas of Bangladesh and these dried fishes have demand both in domestic and international market though the people involved early in the production chain (fishing and drying) add relatively more value and make little profit. The reasons for this less value addition at small- scale producer level are presumed to be the poor product quality. During traditional fish drying, the fish become contaminated by dust, dirt and pathogens. Due to being a very slow process the product become unhygienic by contributing the partial destruction of protein contents of the fish through oxidation and bacterial or enzymatic degradation. The longer duration of drying also causes blowfly infestation and broken pieces. The physical and organoleptic qualities of most of the traditional sun-dried products available in the market are not satisfactory for human consumption (Khan, 1992). For resembling the dried fish as like as fresh fish in flavor and texture texture (particularly softness during chewing) it should be free from ripened flavors caused by prolonged bacterial, enzymatic, oxidative and chemical changes. In this aspect rehydration capacity is considered as one of the most important physical parameters to evaluate the quality of the dried products. Rehydration is a complex process aimed at the restoration of raw material properties when dried material is in contact with water at a certain temperature and time. It is expressed as percent water reconstitution under defined condition. It has been reported that there is a positive relationship between rehydration ability and physical properties of the dried fish products (Reza et al., 2005). Since the physical properties of the dried fish available in the market are poor so the rehydration capacity of these dried fish is not satisfactory. This experiment thus was conducted to develop improved quality sun dried ribbon fish with acceptable rehydration capacity and also to compare the rehydration capacity of the unsalted and salted sundried ribbon fish. Ribbon fish is one of the most popular fishes used for drying in Bangladesh that's why this species was chosen for this experiment.

MATERIALS AND METHODS

Fresh ribbon fish (*Trichiurus haumela*) was collected from fish landing yard of Cox's Bazar. Fish were transported to the Laboratory of Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, in an insulated box with ice (1:1). The facilities of the experiment were developed and installed in the laboratory premises. Sun drying of the fish was completed using ring tunnel dryer. The experiment was conducted from mid July to mid September, 2016.

Sorting

The experimental fish were taken in the laboratory and they were sorted according to general appearance and damaged portion. The sorted fishes were then washed with clean tap water to remove any dirt and undesirable materials attached with the fish body. The whole fish were weighed in a sensitive balance. Fishes were dressed by gutting and evisceration followed by washing and weighing.

Salt treatment

Fishes were divided into three treatments for experimental purpose. These were considered as control dried: (Fish treated with no salt), 15% salt dried (treated with 15% salt (NaCL)) and 25% salt dried (treated with 25% salt (NaCL)) as 3 treatments. Each treatment group was scheduled to have 6-8 fish in duplicate replications. Then 15% and 25% brine solution were made separately in two clean buckets using potable water and fishes in both two treatments (2 and 3) were dipped for 15 minutes.

Dewatering and air drying

Brine treated fish was then kept on two plastic trays after removing them from brine solution. For the completion of air drying the fishes were left in room temperature for about 10 minutes. It was necessary to facilitate the conditioning of fish with salt solution.

Drying

The fishes in different treatments (control dried, 15% and 25% salt dried) were transferred to the vertical ring tunnel (Plate: 1) having 4 sieves inside for sun drying. The fishes were then spread on the sieves inside the tunnel. Four to six fishes were spread on each sieves for perfect drying. Two ring tunnels were used for sun drying of ribbon fish. The tunnel is covered by mosquito net. Using a thermometer the ambient temperature and temperature inside the ring tunnel during drying were recorded carefully. Sun drying on faculty roof top building was continued until the moisture content of the fish apparently was found less than about 15-18%. It was done by considering the gross weight ratio of fresh fish weight and dried fish weight. Complete drying of the fish took about 18-19 hours exposure to sun.

Grading and packaging

The dried fishes were then finally graded according to size, broken products/parts or any other abnormalities. However, no broken part was found in the dried products. After drying, 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 to protect the products from moisture absorption. Each bag contained 7-8 pieces of dried ribbon fish.

Storage of the dried fish products

The prepared dried products were divided into two portions. One portion was kept at ambient temperature and other portion was stored at refrigeration temperature (4^0C). During storage period all 3 types of products were examined at 15 days interval.

Determination of rehydration capacity

For this purpose 5g sample seperately from head, abdomen and caudal region of sundried ribbon fish stored both at ambient and refrigeration temperature were kept immersed in water at temperatures of 28^0C, 40^0C and 60^0C for 60 minutes. Rehydration percentage was measured at every 15 minutes interval for each temperature. Water was drained off through a coarse nylon net. All the fish was then transferred to the strainer and extraneous water was removed off by a piece of blotting paper and fish was weighed. The percent gain of moisture by the fish flesh was expressed as percent water rehydration and was calculated by the following formula-

$$\text{Rehydration capacity (\%)} = \frac{W_r - W_i}{W_i} \times 100$$

Where,

W_i = Initial weight of the dry fish

W_r = Weight of the dry fish after water absorption

RESULT AND DISCUSSION

At the first day of storage water rehydration capacity of control dried, 15% salt and 25% salt dried ribbon fish stored at ambient (28-33^0C) and refrigeration (4^0C) are presented in Table 1.1 and Table 1.2 respectively. At 28^0C the rehydration capacity of control dried, 15% salt and 25% salt dried ribbon fish was within the range of 30.05 to 61.11% with minimum value for 25% salt treated dried fish after 15 minutes soaking in water and maximum value found in control dried ribbon fish after 60 minutes of soaking . At 40^0C the rehydration level of dried ribbon fish was in the range of 32.19 to 67.00% with highest value obtained from control dried fish after soaking in water for 60 minutes and lowest value for 25% salt dried ribbon fish after soaking for 15 minutes. Whereas, at 60^0C temperature water rehydration capacity of dried ribbon fish was in the range of 34.96 to

70.98% with minimum value for 25% salt dried ribbon fish after 15 minutes of soaking and maximum value for control dried ribbon fish after 60 minutes of soaking. After 60 days of storage in ambient temperature the percentage of water re-absorption of dried ribbon fish at 28^0C was in the range of 27.16 to 54.08% with highest value for control dried fish after 60 minutes of soaking and lowest value for 25% salt dried fish after 15 minutes of soaking in water (Table 1.1). At the same temperature the reconstitution level of dried fish stored at refrigeration temperature was in the range of 28.99 to 54.63% with maximum value for control dried fish after 60 minutes of soaking and minimum value obtained from 15% salt dried fish after 15 minutes of soaking (Table 1.2).The changes in water rehydration capacity with time and temperature for the dried fish stored at ambient (28-33^{0}C) and refrigeration temperature (4^0C) are presented in Figure 1.1 and 1.2, respectively. At 40^0C the rehydration level of dried fish products kept at ambient temperature after 2 months of storage was in the range of 28.50 to 55.61% with the lowest value found in 25% salt dried ribbon fish after 15 minutes of soaking and highest value found in control dried fish after 60 minutes of soaking (Table 1.1). On the other hand at the same temperature the rehydration level of the dried ribbon fish stored at refrigeration temperature was in the range of 29.07 to 59.45% with the maximum value for control dried fish after 60 minutes of soaking and minimum value for 25% salt dried ribbon fish after 15 minutes of soaking (Table 1.2). In case of dried ribbon fish stored at ambient temperature at 60^0C the rehydration capacity was in the range of 30.65 to 58.28% with lowest value found in 25% salt dried fish after 15 minutes of soaking and highest value found in control dried fish after 60 minutes of soaking (Table 1.1). At the same temperature the rehydration level of dried fish stored at refrigeration temperature was in the range of 31.78 to 61.43% with maximum value for control dried fish after 60 minutes of soaking and minimum value for 25% salt dried fish after 15 minutes of soaking (Table 1.2). The water rehydration capacity of dried fish decreased gradually with the increasing time of storage. Most probably it happened due to slow increase of moisture in the dried fish. However, it may be assumed that increased soaking time and higher temperature caused the increasing water absorption. This might be due to the fact that increased temperature of water opens the internal structure (intermolecular space) of fish muscle which maximizes the scope of rapid rehydration (Tunde-Akintunde, 2008). From the experiment it was observed that the rehydration capacity of control dried (unsalted) fish was higher than that of salt dried fish. It can be explained by the fact that during brining, water-holding capacity of fish muscles decrease with aggregation of protein (Martínez-Alvarez and Gómez-Guillén 2006). Fennema (1990) suggested that at a relatively low salt concentration, salt anions bind to the filaments and thereby increase repulsive forces between the filaments. Salt was also believed to lessen the structural constraints to swelling. At higher salt concentration the protein denatured, unfolded and the exposure of hydrophobic areas in the proteins increased, leading to aggregation. Cross-linking between proteins and shrinkage of the muscle may have resulted in less space for water and therefore, decreased water holding capacity.

So, the extent and rate of water uptake during rehydration is largely influenced by cellular and structural arrangements in the food matrix since this provides the channels for conveying water to muscle fibers (Niamnuy, 2007). Roy et al. (2014) reported that salt and herbal treated dried products exhibited slightly less rehydration properties compared to unsalted products which might be due to the denaturation of protein that took place during brining process and cause some sort of damage to the cellular structure in an irreversible manner. He also reported that little poor rehydration in salt and herbal treated products compared to controlled products were due to cemented and compact structure of the muscle with few inter fibrillar spaces. Controlled (unsalted) products exhibited higher rehydration rate due to water being carried deep into the pieces by porous structure which absorbed and retained sufficient water by capillary (Jason 1965) which is similar with the present study. Slightly higher rehydration of 60.25% for Bombay duck produced in controlled air drying condition using solar tunnel dryer was reported by Reza et al. (2009). Whereas, Rana (2016) reported that the maximum rehydration in the range of 48.21 to 68.30%, 52.79 to 74.64% and 18.16 to 53.76% were obtained in the samples when soaked at 60^0C for control dried (treated without salt and smoke), salt-smoked-dried and traditionally dried tengra (*Mystus tengara*) and batashi (*Neotropius atherinoides*), respectively. The rehydration capacity of salt smoked dried fish was found comparatively higher than that of the control dried fish. This might happen due to the combined action of salting, smoking and drying process which facilitates more moisture absorption. However, Roy et al. (2014) reported that at 26°C, reconstitution level was found to be varied from 30.00% to 39.27% after 15 minutes of soaking with minimum uptake of water in 4% salt dried Bombay duck and maximum in unsalted dried Bombay duck. After soaking for 60 minutes, the reconstitution properties were between 42.25% and 51.5% with minimum uptake of water in 2% salt dried Bombay duck and maximum in

unsalted dried fish. He also reported that after soaking at 40°C for 60 minutes the highest reconstitution of 50.00% was found in unsalted dried Bombay duck and the lowest of 43.75% in 2% salted dried fish. So, the result of rehydration capacity of salt dried ribbon fish obtained from present study is similar with above mentioned research findings.

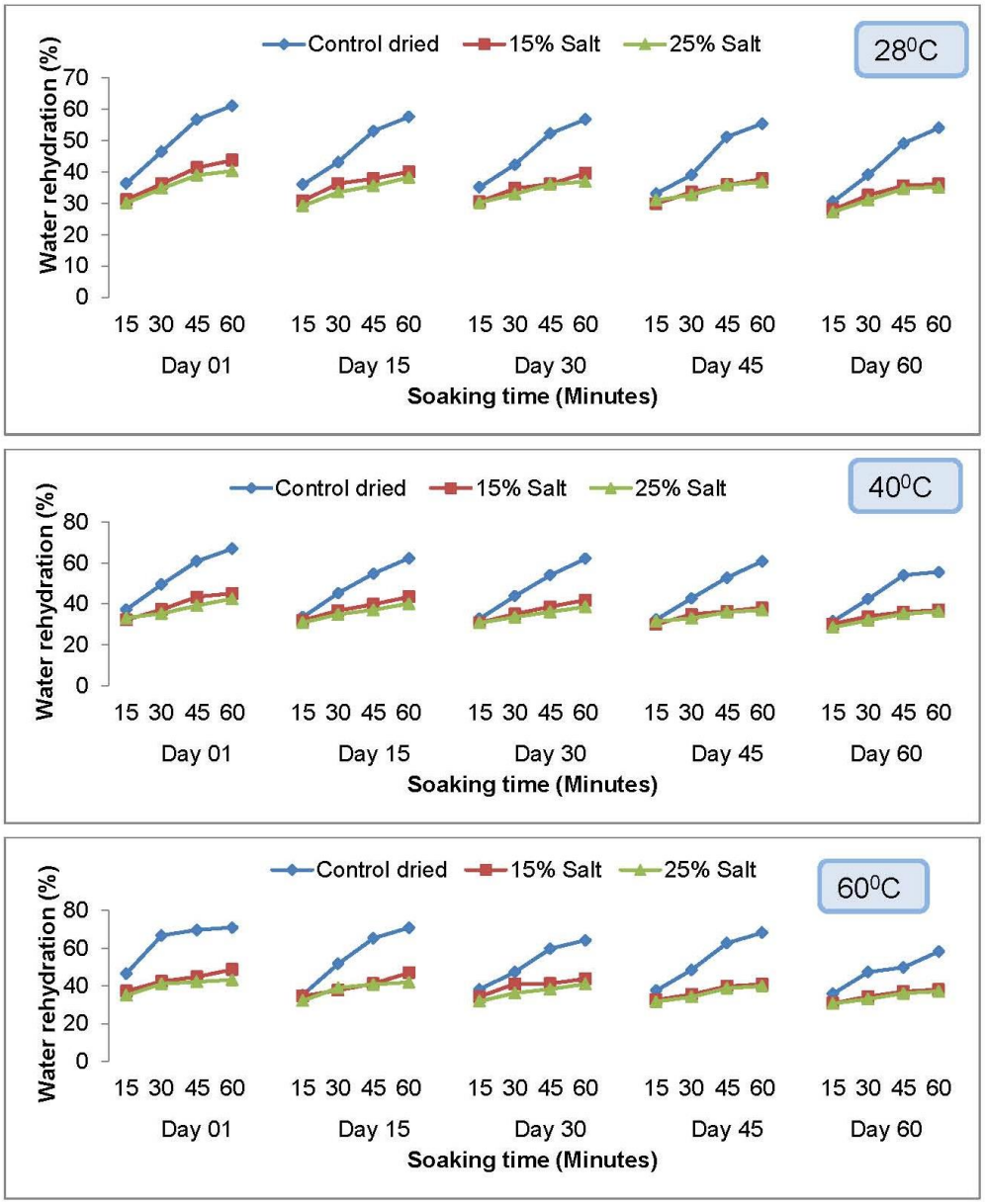

Fig. 1.1: Changing pattern of water rehydration capacity of control dried, 15% salt and 25% salt dried ribbon fish soaked for 15, 30, 45 and 60 minutes at ambient (28^0), 40^0 and 60^0C temperature respectively for the products stored at ambient temperature (28-33^0C)

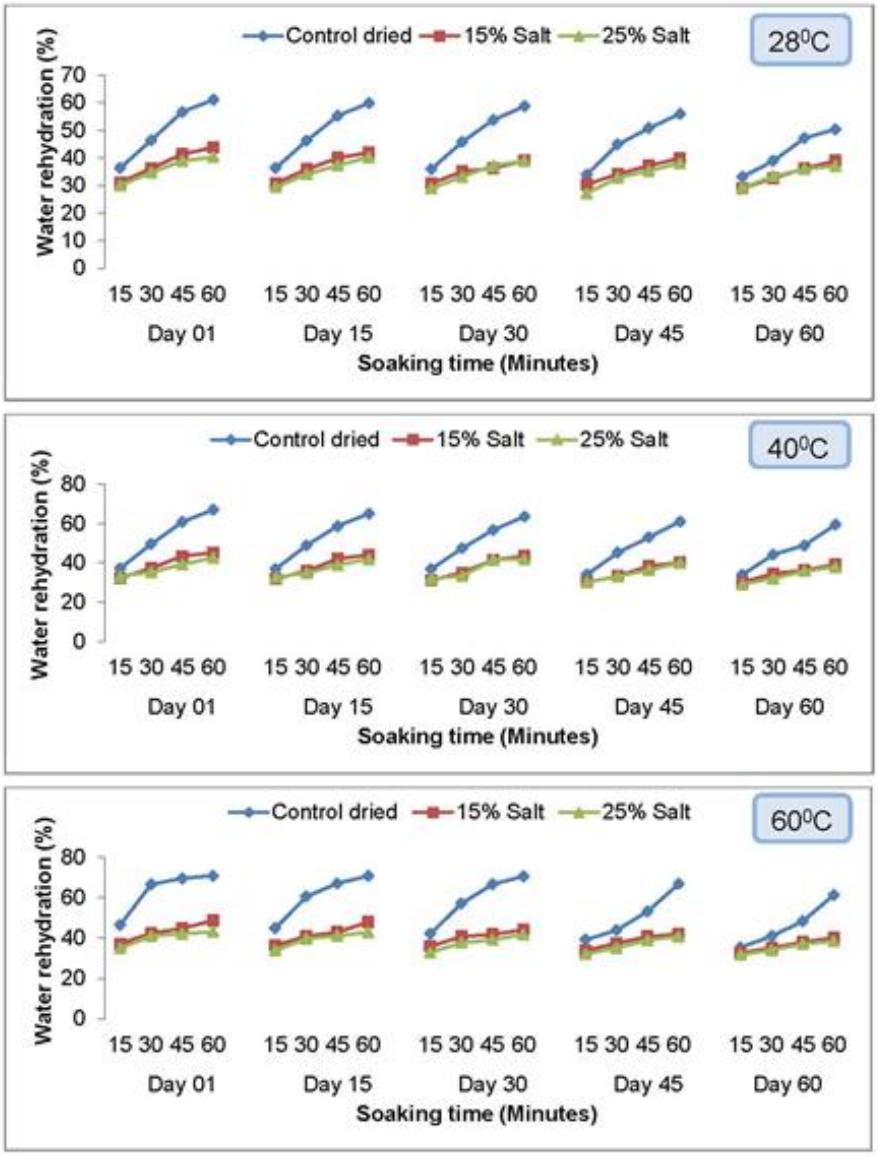

Fig. 1.2: Changing pattern of water rehydration capacity of control dried, 15% salt and 25% salt dried ribbon fish soaked for 15, 30, 45 and 60 minutes at ambient (28^0), 40^0 and 60^{0}C temperature respectively for the products stored at refrigeration temperature (4^{0}C)

Table 1.1. Water Reconstitution Properties expressed as % of control dried, 15% salt dried and 25% salt dried ribbon fish stored at ambient temperature (28-33^{0}C)

Soaking Temperature (^{0}C)	Soaking Time (Min)	1st day			15th day			30th day			45th day			60th day		
		CD	15%	25%	CD	15%	25%	CD	15%	25%	CD	15%	25%	CD	15%	25%
28 Ambient	15	36.33 ±0.05	31.09 ±0.11	30.05 ±0.16	35.95 ±0.09	30.75 ±0.14	29.20 ±0.07	35.15 ±0.11	30.5 ±0.13	30.19 ±0.04	33.13 ±0.03	29.88 ±0.04	31.00 ±0.09	30.50 ±0.08	27.98 ±0.05	27.16 ±0.19
	30	46.47 ±0.09	36.25 ±0.06	34.75 ±0.06	43.15 ±0.14	36.29 ±0.07	33.54 ±0.08	42.33 ±0.06	34.75 ±0.08	32.98 ±0.02	39.04 ±0.10	33.54 ±0.09	32.68 ±0.09	39.06 ±0.07	32.55 ±0.03	31.07 ±0.06
	45	56.70 ±0.11	41.33 ±0.20	38.95 ±0.09	53.06 ±0.17	37.86 ±0.06	35.59 ±0.05	52.30 ±0.08	36.13 ±0.05	35.98 ±0.05	51.16 ±0.08	35.85 ±0.13	35.85 ±0.16	49.08 ±0.02	35.59 ±0.13	34.63 ±0.05
	60	61.11 ±0.04	43.75 ±0.07	40.33 ±0.10	57.55 ±0.06	40.05 ±0.10	38.24 ±0.06	56.77 ±0.13	39.58 ±0.13	36.92 ±0.08	55.39 ±0.13	37.75 ±0.11	36.79 ±0.12	54.08 ±0.04	36.13 ±0.09	35.19 ±0.05
40	15	37.18 ±0.13	33.14 ±0.11	32.19 ±0.15	33.58 ±0.16	31.95 ±0.10	30.87 ±0.07	32.70 ±0.05	30.91 ±0.15	30.74 ±0.18	32.36 ±0.06	29.95 ±0.02	31.51 ±0.08	31.48 ±0.14	30.21 ±0.05	28.50 ±0.08
	30	49.58 ±0.21	37.22 ±0.05	35.29 ±0.22	45.26 ±0.07	36.76 ±0.08	34.85 ±0.06	43.80 ±0.08	35.03 ±0.09	33.52 ±0.23	42.74 ±0.11	34.83 ±0.14	32.98 ±0.10	42.35 ±0.06	33.89 ±0.08	31.98 ±0.36
	45	60.88 ±0.05	43.39 ±0.07	39.18 ±0.24	54.85 ±0.09	39.81 ±0.02	37.06 ±0.19	54.05 ±0.21	38.62 ±0.26	36.09 ±0.09	52.79 ±0.13	36.39 ±0.12	35.92 ±0.14	54.00 ±0.32	35.95 ±0.07	35.06 ±0.10
	60	67.00 ±0.16	45.18 ±0.15	42.55 ±0.04	62.34 ±0.04	43.48 ±0.11	40.11 ±0.05	62.15 ±0.07	41.87 ±0.08	38.60 ±0.06	60.86 ±0.08	38.15 ±0.06	37.05 ±0.06	55.61 ±0.09	37.02 ±0.05	36.36 ±0.04
60	15	46.51 ±0.07	37.18 ±0.18	34.96 ±0.19	35.24 ±0.24	34.59 ±0.05	32.15 ±0.06	38.18 ±0.04	34.20 ±0.08	31.86 ±0.08	37.55 ±0.05	32.66 ±0.09	31.72 ±0.07	35.88 ±0.11	30.85 ±0.09	30.65 ±0.08
	30	66.76 ±0.03	42.40 ±0.10	41.08 ±0.05	51.75 ±0.06	37.69 ±0.11	38.98 ±0.10	47.32 ±0.10	41.12 ±0.05	36.17 ±0.05	48.49 ±0.15	35.45 ±0.07	34.16 ±0.07	47.32 ±0.09	34.35 ±0.14	33.00 ±0.11
	45	69.65 ±0.17	44.81 ±0.22	42.14 ±0.08	65.28 ±0.19	41.24 ±0.12	40.79 ±0.07	59.85 ±0.06	41.20 ±0.11	38.33 ±0.07	62.74 ±0.14	39.80 ±0.05	38.79 ±0.34	49.85 ±0.13	37.08 ±0.13	36.09 ±0.04
	60	70.98 ±0.14	48.69 ±0.08	43.18 ±0.11	70.85 ±0.13	46.95 ±0.04	41.85 ±0.11	64.28 ±0.09	43.75 ±0.11	40.95 ±0.06	68.30 ±0.05	40.91 ±0.07	39.98 ±0.07	58.28 ±0.15	38.07 ±0.16	37.18 ±0.17

***CD=Control dried fish, 15%= 15% salt dried fish and 25%=25% salt dried fish.

Table 1.2. Water Reconstitution Properties expressed as % of control dried, 15% salt dried and 25% salt dried ribbon fish stored at refrigeration temperature (4^0C)

Soaking Temperature (^{0}C)	Soaking Time (Min)	1st day			15th day			30th day			45th day			60th day		
		CD	15%	25%	CD	15%	25%	CD	15%	25%	CD	15%	25%	CD	15%	25%
28 Ambient	15	36.33 ±0.12	31.09 ±0.07	30.05 ±0.05	36.33 ±0.04	30.80 ±0.02	29.38 ±0.12	35.92 ±0.04	30.72 ±0.24	28.90 ±0.25	33.95 ±0.09	30.40 ±0.13	30.22 ±0.09	33.15 ±0.03	28.99 ±0.11	29.14 ±0.17
	30	46.47 ±0.02	36.25 ±0.03	34.75 ±0.06	46.28 ±0.14	35.84 ±0.07	34.11 ±0.21	45.83 ±0.08	35.10 ±0.08	33.25 ±0.09	44.94 ±0.12	34.15 ±0.06	32.80 ±0.07	38.92 ±0.10	32.65 ±0.04	33.38 ±0.05
	45	56.70 ±0.08	41.33 ±0.08	38.95 ±0.22	55.31 ±0.03	39.98 ±0.08	37.30 ±0.11	53.79 ±0.07	36.19 ±0.08	37.15 ±0.07	50.76 ±0.06	37.22 ±0.04	35.34 ±0.05	47.21 ±0.08	36.12 ±0.09	35.91 ±0.08
	60	61.11 ±0.15	43.75 ±0.09	40.33 ±0.18	59.88 ±0.04	42.00 ±0.10	40.27 ±0.04	58.76 ±0.04	39.06 ±0.05	38.91 ±0.10	56.02 ±0.25	39.87 ±0.22	38.01 ±0.06	54.63 ±0.13	38.95 ±0.08	37.05 ±0.10
40	15	37.18 ±0.08	33.14 ±0.02	32.19 ±0.06	36.85 ±0.07	31.85 ±0.11	32.75 ±0.06	36.85 ±0.08	31.25 ±0.11	31.95 ±0.17	34.09 ±0.04	30.00 ±0.08	30.08 ±0.16	33.95 ±0.08	30.01 ±0.13	29.07 ±0.02
	30	49.58 ±0.05	37.22 ±0.11	35.29 ±0.05	48.93 ±0.04	35.88 ±0.11	34.78 ±0.07	47.50 ±0.06	35.00 ±0.09	33.28 ±0.08	45.17 ±0.18	33.20 ±0.06	33.00 ±0.06	44.16 ±0.06	34.50 ±0.11	32.06 ±0.05
	45	60.88 ±0.06	43.39 ±0.08	39.18 ±0.07	58.79 ±0.07	42.09 ±0.08	38.89 ±0.19	56.68 ±0.07	41.49 ±0.06	41.59 ±0.07	52.97 ±0.12	38.31 ±0.04	36.40 ±0.08	48.87 ±0.11	36.14 ±0.02	35.75 ±0.07
	60	67.00 ±0.17	45.18 ±0.07	42.55 ±0.04	64.98 ±0.04	43.98 ±0.04	41.96 ±0.07	63.59 ±0.03	43.48 ±0.07	41.95 ±0.02	61.06 ±0.08	40.19 ±0.09	39.91 ±0.05	59.45 ±0.13	39.18 ±0.14	37.88 ±0.04
60	15	46.51 ±0.13	37.18 ±0.09	34.96 ±0.09	44.92 ±0.06	36.32 ±0.06	33.98 ±0.12	42.18 ±0.05	35.94 ±0.05	32.95 ±0.05	39.15 ±0.04	33.85 ±0.03	32.04 ±0.07	35.36 ±0.08	32.65 ±0.12	31.78 ±0.07
	30	66.76 ±0.11	42.40 ±0.15	41.08 ±0.05	60.67 ±0.08	40.95 ±0.11	39.69 ±0.10	57.23 ±0.09	40.81 ±0.12	37.72 ±0.07	44.03 ±0.06	37.46 ±0.05	35.17 ±0.03	41.05 ±0.05	35.16 ±0.09	34.07 ±0.11
	45	69.65 ±0.14	44.81 ±0.07	42.14 ±0.03	67.18 ±0.13	42.91 ±0.09	41.16 ±0.02	66.71 ±0.12	41.86 ±0.13	39.12 ±0.03	53.28 ±0.06	40.79 ±0.07	38.96 ±0.05	48.41 ±0.07	37.97 ±0.06	37.12 ±0.14
	60	70.98 ±0.04	48.69 ±0.25	43.18 ±0.05	70.89 ±0.08	47.98 ±0.18	42.85 ±0.08	70.70 ±0.07	44.15 ±0.06	41.81 ±0.04	66.96 ±0.07	42.07 ±0.04	40.87 ±0.09	61.43 ±0.15	40.16 ±0.05	38.40 ±0.20

***CD=control dried fish, 15%= 15% salt dried fish and 25%=25% salt dried fish.

CONCLUSION

It was evident from the experiment that the unsalted dried ribbon fish absorbed more moisture than salt dried ribbon fish during 2 months of experimental period. Higher temperature of 60^0C during rehydration of dried fish showed a much higher increased value of moisture absorption in the product. Information obtained from this experiment will be helpful for the producer and hopefully will be preferred by the consumers.

CONFLICT OF INTEREST

None to declare.

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