International Journal of Advanced Scientific Research
ISSN: 2456-0421; Impact Factor: RJIF 5.32
www.allscientificjournal.com
Volume 1; Issue 5; August 2016; Page No. 16-21

Effect of ripening period of dry salting process in three freshwater fish species of Bangladesh

[1] Farzana Binte Farid, [2] Dr. Gulshan Ara Latifa, [3] Dr. Shubhash Chandra Chakraborty, [4] Mosarrat Nabila Nahid, [5] Mohajira Begum

[1, 2, 4] Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh
[3] Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh
[5] Institute of Food Science and Technology, Bangladesh Council of Scientific and industrial Research (BCSIR), Dhaka, Bangladesh

Abstract
A clear understanding on the difference between the biochemical and mineral-composition and bacterial-count of fresh and dry-salted shol, taki and tengra fish products have been assessed by analyzing the changes in salt penetration rate and its effect on moisture content, fluid loss pattern in fish-muscles and percent weight loss of these fishes during 7 days of ripening period. After ripening-period, values of moisture (%) and pH were decreased whereas protein (%), fat (%), ash (%), salt (%), TVB-N, FFA (%) and mineral content (Ca, Mg, Fe, Cu, Zn, Mn) increased significantly in these three fishes. It was also observed that in comparison with the fresh fish, there was a decrease in total bacterial count which may be due to the presence of high salt concentration, so the pathogenic microorganism growth is controlled. Experimentally it has been proved that ripening period of dry-salting method have positive effects in these three fishes.

Keywords: Salt-ripening, dry-salting, freshwater fish, biochemical-composition, bacterial-count

1. Introduction
It is well accepted that fish are a good source of animal protein throughout the world. Fish flesh generally contains up to 80% moisture, 15-25% protein, 1-2% mineral matter [1]. The composition of a particular species often appears to vary from one habitat to another, and season to season, but the basic causes of change in composition are usually variation in the amount and quality of food it eats and in the amount of movement it makes [2]. In this research works it was considered three freshwater fish species viz; large size shol (*Channa striatus*) fish, medium size taki (*Channa punctatus*) fish, and small tengra (*Mystus tengra*) fish for dry-salting. The size variation of selected fish species for present experiments bears significant consideration. Rahman stated that, soft textured fish tend to absorb salt faster than tough or firm-textured fish [3]. He also stated that high fat content fish absorb salt slower than low-fat fish. The small indigenous species of fishes in Bangladesh are generally considered to be those which grow to a length of approximately 5-15 cm at maturity [4]. It is assumed that the size of fishes considered to be selected for preparing any processed product has got some significance on the quality of the product. Therefore, consideration of different fat content and different sizes of experimental fish species in this research work may be considered as justifiable. The initial quality of fresh fish material strongly influences subsequent performance in salting.

Dry-salting process is considered as one of the oldest methods of fish preservation and this process is still been used in several places around the world. Dry-salting is generally aimed at reducing water activity (a^w) to reduce, obstruct or destroy the growth of the microorganism as well as inactive autolytic enzymes, where at the end, the fish meat goes its way to durability [5, 6]. The aim of dry-salting is not only to prolong the shell life of fresh fish but also to provide desirable sensorial changes [7, 8]. The role of salt is highly significant to guarantee the quality and stability of the finished products. The preservative action of salt lies in the reduction of water activity of a system thus renders a condition less favorable for the microbial life [9, 10]. Dry-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.

During salting process, the changes in chemical and physico-chemical characteristics takes place and in certain stage, the original characteristics of the fresh fish 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 [11]. A series of complex biochemical processes including proteolysis, lipolysis and lipid oxidation takes place during ripening stage. The physical and chemical changes that occur during ripening, determine the overall sensory qualities of salted fish-products [12]. Borgstrom reported that salt ripening is the autolytic phenomena caused by the enzyme of the muscle or gastrointestinal tract [13]. 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. It is generally accepted that salt migration by diffusion plays an important role in the salting of fish.

2. Materials and methods
2.1 Collection of the fishes
Three different sizes freshwater fish species; large size Shol (*Channa striatus*) fish, medium size taki (*Channa punctatus*) fish and small Tengra (*Mystus tengra*) fish had been collected from the river Meghna in the early hours of the day.

2.2 Handling of experimental fishes in laboratory
Being air breathing fish, shol and taki fish were transported to the research laboratory in dram full with water. In case of tengra fish they were carried in clean, good quality sterile polythene bag with ice in order to keep the fish fresh and avoid any type of microbial contamination.

2.3 Place of the experiment
Biochemical analysis and Microbial analysis were carried out at the 'Fish Technology Section' and 'Food Microbiology Section' of the Institute of Food Science and Technology (IFST) of Bangladesh Council of Scientific and Industrial Research (BCSIR), and from center for Advanced Research in Sciences (CARS) Dhaka, Bangladesh for Minerals.

2.4 Preparation of fishes
The fishes were carefully washed with cooled tap water. 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 and head of shol and taki are discarded as the waste.

2.5 Sampling procedure
About 6 or 7 slices of shol and taki fish was taken randomly which represented the parts from whole body of the fish and a few tengra fish species was taken. Then they were chopped with skin and finally ground with an electric blender to make a homogenous sample before being sampled for quality. In case of dry-salted fish-samples, salt crystals (if any) were removed from fish-samples by using tissue paper.

2.6 Method of Dry-salting
The fresh fishes were enrolled by dry commercial salt (NaCl) of about 30% by weight of the dressed fish (fish weight: salt weight 3:1), stacked in containers and stored for a salting or curing period, at room temperature. In this method, the extracted water of the fish due to salt action had been removed from the container. Thus the fishes are always allowed to remain in dry condition for the production of dry salt cured fish.

2.7 Ripening period after dry-salting process
According to Vokresensky the ripening of the fish was observed after 7 to 10 days of salting fish [11]. During salting process moisture content decreased and salt content increased considerably during the first 6 to 7 days. On the basis of the observation, the process of salting of fish can be divided into three stages. In the first stage, the fish was exposed to high osmotic pressure. At this stage, the active movement of salts towards inside the fish flesh accompanied by rapid diffusion of water from the fresh to outside salt solution took place which resulted a considerable decline in weight of the fish. This phenomenon is markedly evident in first day of salting. From the second day of salting, osmotic pressure believed to still exert influence although on a reduced scale and there was no great difference in the rate of salt moving into the fish or water leaving the fish. This process continued until 6 days of salting. This phenomenon is considered to be second stage of salting. Between 7-8 days, minor quantities of salt were found to move into the fish & movement of water almost ceased. In this period, the salt concentration of salt in the surrounding fish surface. This period could be considered third stage in which the meat of the fish became dense & has a salty taste and the odor & taste of the fresh fish ware disappeared.

2.8 Parameters of quality assessment
The analytical methods used in this experiment are given below**:**

- The moisture, fat, ash and salt contents of the fishes were determined by AOAC method [14].
- The crude protein of the fishes was determined by Micro-Kjeldhal method as described by Pearson [15].
- TVB-N was determined by Conway modified micro-diffusion technique as described by Conway and Byrne [16].
- FFA of the fishes were determined by AOAC method [17].
- pH was determined using a pH meter [18].
- Samples for mineral analysis were prepared according to recommendations of Perkin Elmer's procedures of Atomic Absorption Spectrometer [19].
- Bacteriological study (SPC and HBC) was done according to the standard methods of AOAC and FDA BAM [20, 21].

2.9 Statistical analysis
Data were analyzed by using SPSS for windows-20 statistical programme.

3. Results & Discussion
3.1 Changes in salt penetration rate and its effect on moisture content during ripening period in experimental fishes
Changes in salt penetration rate and its effect on moisture content during ripening period in experimental fishes is presented in Table 1.

Table 1: Changes in salt penetration rate and its effect on moisture content in dry salting process of three experimental fish species Shol, Taki and Tengra during 7 days of ripening period

Days of ripening period	Dry salted Shol		Dry salted Taki		Dry salted Tengra	
	Moisture (%)	Salt (%)	Moisture (%)	Salt (%)	Moisture (%)	Salt (%)
0*	77.03	0	78.65	0	74.27	0
1	64.57	4.6	68.48	6.1	60.73	7.2
2	54.15	8.4	56.39	10.3	54.23	10.9
3	52.01	11.1	52.38	12.52	49.70	12.5
4	51.40	13.6	50.00	13.16	45.68	14.08
5	50.15	14.5	48.43	14.47	42.22	15.33
6	49.00	15.11	47.90	15.35	41.81	16.60
7	48.84	16.00	46.21	16.06	41.41	16.80

*= Initial (Fresh fish)

The moisture content of dry-salted shol, taki and tengra fish was observed in 48.84%, 46.21% and 41.41%, respectively during ripening period of 7 days. On the other hand, salt content gradually increased in dry-salted shol, taki and tengra fish and was observed in 16.00, 16.06 and 16.80 respectively during ripening period of 7 days. Moisture content and salt percentage play an important role in the keeping quality of salt-cured fish products [22]. During salting, the mass transfer occurs basically between salt and water: the fish-muscle takes up salt and loses water [23, 24]. Many workers agree that maximum salt uptake takes place within 6-7 days of salting without further uptake during subsequent storage [25, 26, 27]. Similar results also obtained in the present study where the fish contained maximum salt content in 7 days of dry-salting. The rates of water diffusion are positively correlated with increasing of salt concentration which is very important with regard to weight change and quality of the final product [28, 29].

3.2 Fluid loss pattern in fish muscles during ripening period

From first day of dry-salting considerable amount of fluids started to be diffused from the fish flesh. From second day, the quantity of fluid loss decreased gradually until the loss of fluids ceased in 6-7 days. Ripening period ends when the salt concentration of fish tissue under osmotic diffusion becomes equal to the concentration of salt in the surrounding solution. After the salt concentration in the cellular fluid of various parts of the fish body reaches to 15-20%, the bound water (30-35%) is converted to 'Free State' [30, 31, 32]. The dry salting method produced considerable loss of water due to heavy uptake of salt [33]. Present result is more or less in agreement with those suggests that maximum water loss take place when salt concentration in the fish body approaches to about 15%. The decrease of moisture or loss of fluid in dry-salted fish products are simply a result of curing due to salt penetration in the fish tissue and in all the 3 cases salting resulting in the loss of moisture due to osmosis diffusion, the moment the fish surface came into contact with salt. Attempts were also made to quantify the amount of fluid that lost during ripening period which is presented in Figure 1. The fluid loss pattern showed a sharp decrease on first three days followed by a slow decrease of fluid up to 7 days of ripening period in dry-salted shol and taki fish whereas dry-salted tengra showed a sharp fall of fluid on the first two days followed by slower decreased up to ripening becomes completed.

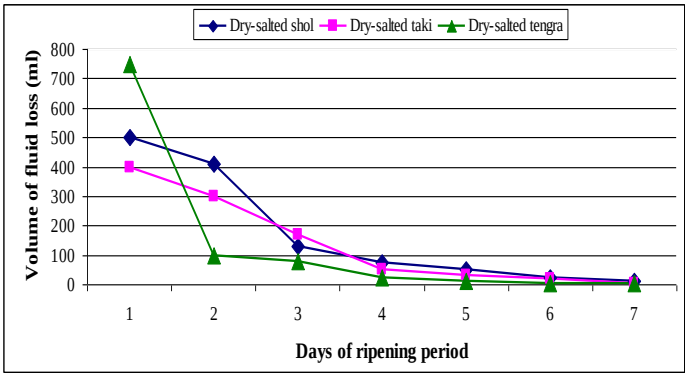

Fig 1: Fluid loss pattern during 7days of ripening period in dry-salted shol, taki and tengra fish products

3.3 Percent weight loss of fishes during ripening period

The comparative features of changing pattern of weight loss (%) of dry salted shol, taki and tengra fish during ripening period are shown in Figure 2. It is clear here that the weight of dry-salted fishes gradually decreased throughout the ripening period and this may occur due to maximum water was coming out from the fish flesh because of osmosis and diffusion. This type of weight loss was observed as reported by several researchers during salting of fish [34, 35, 32, 36, 37]. The relationship between changes in weight, salt and water contents is almost linear. From the figure it is shown that, significantly higher amount of weight loss observed in dry-salted taki fish whereas, the least percent weight loss was found in dry-salted tengra fish-products.

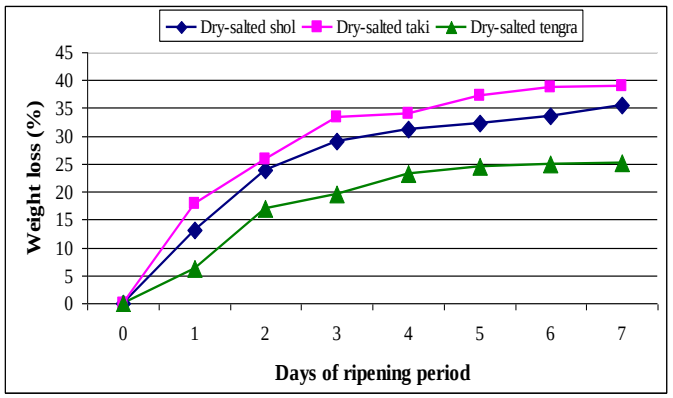

Fig 2: Weight loss (%) of dry-salted shol, taki and tengra fish during ripening period

3.4 Bio-chemical composition

Bio-chemical composition of fresh and dry-salted shol, taki and tengra fish are shown in Table 2.

Table 2: Mean bio-chemical composition of fresh and dry salted shol, taki and tengra fish

Experimental fishes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	TVB-N (mgN/100g)	FFA (%)	pH
Fresh shol	77.03±0.12	19.52±0.07	1.93±0.07	1.44±0.11	-	4.41±0.01	0.6±0.06	6.9±0.06
Dry-salted shol	48.84±0.06	28.21±0.01	3.99±0.01	18.98±0.01	16.00±0.05	5.25±0.01	1.5±0.15	6.3±0.10
Fresh taki	78.65±0.07	16.89±0.10	2.50±0.06	1.36±0.11	-	3.43±0.02	0.5±0.10	7.0±0.06
Dry-salted taki	46.21±0.04	23.58±0.01	3.93±0.01	26.37±0.02	16.06±0.06	4.18±0.00	1.9±0.15	6.5±0.06
Fresh tengra	74.27±0.07	16.96±0.07	6.04±0.06	2.67±0.08	-	4.27±0.02	0.9±0.21	7.0±0.10
Dry-salted tengra	41.41±0.04	22.05±0.01	10.65±0.03	26.15±0.04	16.80±0.03	3.90±0.02	2.8±0.21	6.0±0.11

Values are shown as mean ± standard deviation of triplicate measurements

In present study, fresh and dry salted shol, taki and tengra fish-products, moisture (%) content were 77.03±0.12 and 48.84±0.06, 78.65±0.07 and 46.21±0.04%, 74.27±0.07 and 41.41±0.04%; protein (%) content were 19.52±0.07 and 28.21±0.01%, 16.89±0.10 and 23.58±0.01%, 16.96±0.07 and 22.05±0.01%; fat (%) content were 1.93±0.07 and 3.99±0.01%, 2.50±0.06 and 3.93±.01%, 6.04±0.06 and 10.65±0.03%; ash (%) content were 1.44±0.11 and 18.98±0.01%, 1.36±0.11 and 26.37±0.02%, 2.67±0.08 and 26.15±0.04%; TVB-N content were 4.41±0.01 and 5.25±0.01, 3.43±0.02 and 4.18±0.00, 4.27±0.02 and 3.90±0.02 mgN/100g of fish; FFA (%) value were 0.6±0.06 and 1.5±0.15 %, 0.5±0.1 and 1.9±0.15%, 0.9±0.21 and 2.8±0.21%; pH value were 6.9±0.06 and 6.3±0.10, 7.0±0.06 and 6.5±0.06, 7.0±0.10 and 6.0±0.11 respectively. On the other hand, salt (%) content of dry-salted taki, shol and tengra fishes were 16.00±0.05, 16.06±0.06 and 16.80±0.03% respectively. In comparison of fresh fish, the dry-salting process resulted in a significant decrease in moisture (%) and pH value and a significant increase in protein, fat, ash, TVB-N and FFA value in dry-salted fish samples. This is consistent with the observations by Abraham-Olukayode *et al.* [38]. Nutritional components, such as protein, lipid, and ash, were increased due to the loss of water in fish muscle in the salting process [39, 23]. Significant increase in protein levels ($p<0.05$) in all salted fish-products when compared with the fresh fish, suggested that protein nitrogen was not lost during salting [40]. The higher value of total ash content in dry-salted fishes than fresh fishes were attributed to high salt content which added more ash components to the products. These results were in accordance with El-Bassir *et al.* [41]. The FFA (%) value recorded in this work is low and hence there is no fear of rancidity. This agrees with the work of Frazier and Westhoff [42]. The salting process caused a decrease in pH values in dry-salted fish samples. Goulas observed that pH values of mackerel (*Scomber japonicus*) decreased after salting [43]. After salting of Anchovies, salt content increased from 0.32 to 19.3%, ash content increased from 1.6% to 21% and pH decreased from 6.13 to 5.72 which are in harmony with present findings [44]. 30% dry salted punti fish had salt content of 24.21% and chapila fish had salt content of 25.11% respectively which is higher from present study [45].

3.5 Mineral contents

The mineral composition of fresh and dry salted shol, taki and tengra fish-products are shown in Table 3.

Table 3: Important mineral (mg/100g of fish) composition in fresh and dry-salted shol, taki and Tengra

Experimental fishes	Ca mg/100g	Mg mg/100g	Fe mg/100g	Cu mg/100g	Zn mg/100g	Mn mg/100g
Fresh shol	11.2	10.125	1.475	0.7	0.25	0.1
Dry-salted shol	438.75	83.69	2.65	0.275	2.125	0.45
Fresh taki	16.35	9.425	1.275	0.65	0.425	0.05
Dry-salted taki	600	147.75	3.75	0.425	1.525	0.625
Fresh tengra	22.025	11.4	2.25	0.55	1.275	0.125
Dry-salted tengra	1250	520.5	4.3	0.435	2.175	0.65

In case of fresh and dry salted shol, taki and tengra fish-products, Ca (calcium) content were 11.2 and 438.75 mg/100g, 16.35 and 600 mg/100g, 22.025 and 1250 mg/100g of fish; Mg (magnesium) content were 9.425 and 147.75 mg/100g, 10.125 and 83.69 mg/100g, 11.4 and 520.5 mg/100g of fish; Fe (iron) content were 1.475 and 2.65 mg/100g, 1.275 and 3.75 mg/100g, 2.25 and 4.3 mg/100g of fish; Cu (Cooper) content were 0.7 and 0.275 mg/100g, 0.65 and 0.425 mg/100g, 0.55 and 0.435 mg/100g of fish; Zn (zinc) content were 0.25 and 2.125 mg/100g, 0.425 and 1.525 mg/100g, 1.275 and 2.175 mg/100g of fish and Mn (manganese) content were 0.1 and 0.45 mg/100g, 0.05 and 0.625 mg/100g, 0.125 and 0.65 mg/100g of fish respectively.

From table 3 it is clear that dry-salting method raised the mineral composition of dry salted shol, taki and tengra fish products. There is very little information on mineral contents of salted fish-products. However, the present values are comparable with the results reported for some dry freshwater fish [46, 47]. According to Begum *et al.* freshly processed salted-dried punti (*Puintius sophore*) fish have calcium (Ca) and Iron (Fe) was in a range of 320-330 mg/100g and 3.1-3.9mg/100g of fish respectively [48].

3.6 Bacteriological study

Standard plate count (SPC) (cfu/g) and halophilic bacterial count (HBC) (cfu/g) of fresh and dry-salted shol, taki and tengra fish-products are given in Table 4. The Standard plate count (SPC) in fresh shol, taki and tengra fish were recorded in 2×10^5, 1.1×10^5 and 5×10^5 cfu/g and dry-salted shol, taki and tengra fish were 2.7×10^3, 4.0×10^3 and 5×10^5 whereas halophilic bacterial count of these three dry-salted fishes were 3.0×10^2, 3.0×10^2 and 3.2×10^2 cfu/g respectively. According to Surendran the acceptable limit for bacterial count is 5×10^5 cfu/g for fresh fish which is in accordance with present findings of these three fresh fishes [49]. On the other hand dry salted shol, taki and tengra fish-products also indicated an acceptable microbial load ($<10^5$ cfu/g-1) [50].

Table 4: Standard plate count (SPC) (cfu/g) and Halophilic bacterial count (HBC) (cfu/g) of fresh and dry salted shol, taki and tengra fish-products

Storage period (Month)	SPC	HBC
Fresh shol	2×10^5	-
Dry-salted shol	2.7×10^3	3.0×10^2
Fresh taki	1.1×10^5	-
Dry-salted taki	4.0×10^3	3.0×10^2
Fresh tengra	5×10^5	-
Dry-salted tengra	3.8×10^3	3.2×10^2

From table 4 it was observed that in comparison with the fresh fish, there was a decrease in total bacterial count which may be due to the presence of high salt concentration, so the pathogenic microorganism growth is controlled. This result is in agreement with the findings of Abu Giddeire [51]. According to Abbas Bakhiet and Khogalie, salting process reduces total bacterial count of *Hydrocynus spp* fish and found that TVC of

fresh fish was 58.1×10^3 and it reduces in freshly processed 15%, 20% and 25% salted fish-products in 10.0×10^3, 7.8×10^3 and 4×10^3 respectively which is in agreement with the present study [52]. When the water activity is considerably reduced, most microorganisms become inactive but haploidic microorganisms become the major causes of microbial spoilage [53]. The high salt concentration leaves only salt tolerant microorganisms to survive [6].

4. Conclusions

The present study reveals that ripening of dry-salting process have a positive significant role on the biochemical and mineral composition of three different sizes freshwater fishes; shol, taki and tengra and reduces bacterial load as well as makes them nutritionally suitable for all. This work has elucidated more on the importance of dry-salted freshwater fishes as good sources of protein and minerals and broadened our knowledge on the nutritional value of dry-salted fishes. Commercial traders those who produce market dry-salted fishes in our country may be asked to follow the suggestions made over here on the basis of the findings of the present study.

5. Acknowledgments

The author acknowledges the scientists and technicians of BCSIR and CARS, Dhaka, Bangladesh for their technical supports and continuous assistance to carry out the present study. The author also acknowledges "Bangabandhu Fellowship" on Science & ICT Project for financial support.

6. References

1. CSIR. Fish and Fisheries raw materials, India. 1962; IV:132.
2. Murray J, Burt JR. The composition of fish. Torry Advisory Note 3. www.fao.org/wairdocs/tan/x5916e/x5916e00.htm, 2009.
3. Rahman MM, Jahan SS, Begum M, Khan S. Post-harvest handling, Processing and Quality control of fish. Paper presented at National Workshop on food Processing and Analytical Technique held in 5-8th, 2001.
4. Felts RA, Rajts F, Akhteruzzaman M. Small indigenous fish species culture in Bangladesh. IFADEP Sub-Project-2. Development of Inland Fisheries, 1996, 41.
5. Ashie INA, Smith JP, Simpson BK, Haard NF. Spoilage and shelf-life extension of fresh fish and shellfish. Critical Rev. Food Sci. Nutr. 1996; 36:87-121.
6. Horner WFA. Preservation of fish by curing (drying, salting and smoking). In: Fish Processing Technology. Blackie Academic & Professionals, New York. 1997, 31-71.
7. Ahmed ATA, Mustafa G, Rahman M. The effect of temperature and quality changes during storage, handling and preservation of *Cypriuis carpio* (L). Proc. 3rd Nat. Zool. Conf. 1981, 126-129.
8. Andres A, Rodriguez-Barona S, Barat JM, Fito P. Salted Cod Manufacturing: Influence of salting procedure on process yield and product characteristics. J Food Eng. 2005; 69:467-471.
9. Barbut S, Tanaka N, Maurer AJ. Effects of varying levels of chloride salt on *Clostridium botulinum* toxin production in Turkey Frankfurters. J Food Sci. 1986; 51(5):1129-1131.
10. Luck E, Jager M. Antimicrobial Food Additives, In: Characteristics, Uses and Effects. 2nd Ed. New York: Springer Verlag. 1997, 1-23.
11. Voskresensky NA. Salting of herring. In fish as food, by G. Brogstorm. Academic press, New York, London. 1965. 3:107-131.
12. Sikorski ZE, Gildberg A, Ruiter A. Fish and fishery products. In: Consumption, Nutritive properties and Stabality, Ruiter, A. (Ed), CAB International Wallingford UK. 1995, 315.
13. Borgstrom G. Fish as food, Academic press, New York and London. 1965, 4-518.
14. AOAC (Association of Official Analytical Chemist). Official methods of Analysis (15th ed.). Inc., Suite, 400, Arlington, Virginia. 1990; 2:685-1298.
15. Pearson D. Pearson's composition and analysis of foods. University of Reading, 1999.
16. Conway EJ, Byrne A. Micro- diffusion analysis of TVN. Biochem. J. 1933; 27:419-429.
17. AOAC (Association of Official Analytical Chemist). Official methods of Analysis (17th ed.). 2000.
18. Vyncke W. pH of fish muscle comparison of methods, Western European Fish Technologists Association (WEFTA), Copenhagen, Denmark. 1981.
19. Perkin-Elmer. Analytical Methods for Atomic Absorption Spectroscopy. The Perkin Elmer Inc. USA. 1996.
20. AOAC (Association of official analytical chemist). Official methods of Analysis (12th ed.).Washington DC. 1995, 832.
21. FDA BAM. Bacteriological analytical manual, Aerobic plate count Chapter. 3, 2001.
22. El-Sharnouby SA. Chemical and technological studies on fish "Role of enzymes in determining the quality of salted and cured fish. Ph. D. Thesis, Fac. of Agric., Alex. Univ., Egypt. 1989.
23. Chaijan M. Physicochemical changes of tilapia (*Oreochromis niloticus*) muscle during salting. Food Chemistry, 129:1201-1210. Retrieved from http://dx.doi. org/10.1016/j.foodchem. 2011.
24. Oliveira H, Pedro S, Nunes ML, Costa R, Vaz-Pires P. Processing of salted cod (*Gadus spp*.). A Review. Comprehensive Reviews in Food Science and Food Safety. 2012; 11:546-564.
25. Narayanaswamy D, Rao CVN, Govindan TK. Penetration of sodium chloride during prolonged salting of fish. Fishery Technol. 1980; 17(1):63-64.
26. Leitao MF, De F, Beraquet NJ, Mantovani DMB, Teixeira Neto RO, Angelucci E, et al. Variation of water activity, moisture content and salt concentration during salting of whole and nob bed sardines, and growth of *Clostridium botulinum* type A and *Staphlocococcus aureus* during salting. Baletin do Instituto de Technologia de Alimentos, Brazil. 1983; 20(2): 131-159.
27. Simmonds CK. Salting and Drying of hake. Annual Report, Fishing Industry Research Institute, Cape Town. 1984; 38:36-37.
28. Bellagha S, Sahli A, Farhat A, Kechaou N, Glenza A. Studies on salting and drying of sardine (*Sardinella aurita*): Experimental kinetics and modeling. J Food Eng. 2007; 78: 947-952.

29. Boudhrioua N, Djendoubi N, Bellagha S, Kechaou N. Study of moisture and salt transfers during salting of sardine fillets. J of Food Eng. 2009; 94:83-89.
30. Akiba M. Discussion on the variation in the amount of bound water in fresh meat during the processing of marine food products. Bull. Japan Sco. Sci. Fisheries. 1955; 20(1):937-940.
31. Akiba M. Studies on the bound water in fish muscle. Memo. Fac. Fisheries, Hokkaido University. Japan. 1961; 9:85-179.
32. Voskresensky NA. Technology of Salting, Smoking and Drying Fish, Moscow (In Russian). 1958, 546.
33. Martínez-Alvarez O, Gomez-Guillén MC. Effect of brine salting at Different pH on the functional properties of cod muscle proteins after subsequent dry salting. Food Chem. 2006; 94:123-129.
34. Voskresensky NA. Kineties of the fish salting process (In Russian). Trudy VNIRO. 1952; 20:56-76.
35. Voskresensky NA. Kineties of the Okhotsk Sea Herring Salting (In Russian). (Rybnoe khoz). 1953; 29(3):55-59.
36. Minder LP. The influence of some factor upon the changes of weight of the fish during salting (in Russian). Trudy Vniro. 1952; 23:48-141.
37. Semenov NA, Makarova APJ. Course of preservation in salt during barrel type salting of Herring (In Russian) Rybnoe Khoz. 1953; 29:55-58.
38. Abraham-Olukayode AO, Adejonwo OA, Oramadike CE, Kolade OY. Proximate Composition of *Pseudotolithus elongatus* Subjected to Different Processing Techniques. J of Fish and Aquat. Sci. 2012; 8(1):282-286.
39. Bras A, Costa R. Influence of brine salting prior to pickle salting in the manufacturing of various salted dried fish species. J of Food Eng. 2010; 100:490-495. Retrieved from http://dx.doi.org/10.1016/j. jfoodeng.2010.04.036
40. Nahid MN, Latifa GA, Chakraborty SC, Farid FB, Begum M. Comparative study of biochemical composition and sensory characteristics of salt and garlic treated smoke-dried Chapila (*Gudusia chapra*, Hamilton; 1822) and Guchi Baim (*Mastacembelus pancalus*, Hamilton-Buchanan; 1822) stored at refrigeration temperature (4^0C). J of Agric. and Vet. Sci. 2014; 7(11):01-07.
41. El-Bassir ARHA, Karrrar AMH, Salih AEMGH, Mohamed HA, Yagoub RS. The Effect of Sun Drying on the Nutritive Value of *Bagrus bayad*. American Res. Thoughts. 2015; 1(8):1701-1712.
42. Frazier WC, Westerhoff HI. Food Microbiology. Tata MeGraw Hill Publishing Company Limited. New York. 1998, 243-252.
43. Goulas AE, Kontominas MG. Effect of salting and smoking method on the keeping quality of chub mackerel (*Scomber japonicus*): biochemical and sensory attributes. Food Chem., 2005; 93:511-520.
44. Hernandaz-Herrero MM, Roig-Saugues AX, Lopez-Sabater EI, Rodrigueez-Jerez JJ, Mora-Venturaa MT. Total volatile basic nitrogen and other physicochemical and microbiological characteristics as related to ripening of salted Anchovies, J Food Sci. 1999; 64(2):344-347.
45. Monsur M. A comparative study on the performance of different methods of processing and preservation of *Puntius stigma* (Hamilton-Buchanan, 1822) and *Gudusia chapra* (Hamilton-buchanan, 1822) fish and their quality assessment in the laboratory. MS Thesis. Department of fisheries. University of Dhaka. 2007, 86.
46. Ahmed A, Ahmadou D, Saidou C, Tenin D. Influence of traditional drying and smoke-drying on the quality of three fish species (*Tilapia nilotica, Silurus glanis* and *Arius parkii*) from Lagdo Lake, Cameroon. J Animal Vet. Advan. 2011; 10(3):301-306.
47. Mohamed EHA. The Nutrient contents of Traditional sun-dried Nile Fish in Sudan. Asian J. of Sci. and Technol. 2013; 4(11):199-202.
48. Begum M, Akter F, Ahmed ATA, Khaleque MA. Comparison and quality Assessment of dried punti fish (*Puntius sophore*; Hamilton-Buchanan, 1822) both at commercial and laboratory level. Int. J of Sustain. Agril. Tech. 2012; 8(8): 45-51.
49. Surendran P, Nirmala Thampuran K, Narayanannambiar V, Lalitha KV. Laboratorymanual on microbiological examination of seafood, CIFT, Cochin, 2nd Ed. 2006.
50. ICMSF (International Commission on Microbial Specifications in Foods). Microorganisms in Foods. Application of Hazard Analysis Critical Control Point System to ensure microbiological safety and quality. Blackwell Scientific Publications. 1988.
51. Abu Gideiri OO. Some biochemical and microbiological aspects of fesseikh industry in Sudan. B.Sc. (Honors) dissertation Department of Zoology, University of Khartoum, Sudan. 2001.
52. Abbas Bakhiet HH, Khogalie FAE. Effect of different salt concentration on total bacterial count and heavy metal composition of the fish *Hydrocynus spp.* Online J. of Anim. and Feed Res. 2011; 3 (2): 87-90.
53. Ames G, Clucas IJ, Paul SS. Post-Harvest Losses of Fish in the tropics. Report on the Natural Resources Institute. 1991. 1-22.