

## Comparative study of physical, chemical, microbiological and sensory aspects of some sun dried fishes in Bangladesh

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**Abstract.** An investigation was carried out to compare the physical, chemical, microbiological and sensory properties of three freshwater dried fish products of *Wallago attu* Bloch & Schneider, 1801 (Siluriformes: Siluridae), *Channa striatus* (Bloch, 1793) (Perciformes: Channidae) and *Glossogobius giuris* (F. Hamilton, 1822) (Perciformes: Gobiidae). The traditionally sun dried fishes were collected from Kawran Bazar Fish Market, Dhaka, Bangladesh. Results showed that the water reconstitution properties varied among the dried fishes where maximum rehydration was observed in the *C. striatus* at room temperature, 40 °C and 60 °C. Moisture content of *W. attu*, *C. striatus* and *G. giuris* were 22.70% ± 0.45%, 18.75% ± 0.58% and 21.93% ± 0.54%, respectively; the protein content were 61.85% ± 0.99%, 66.44% ± 1.02% and 62.83% ± 0.87%, respectively; the lipid content were 6.21% ± 0.93%, 6.81% ± 0.72% and 5.98% ± 0.55%, respectively, and the ash content were 6.79% ± 1.11%, 6.49% ± 1.29% and 7.83% ± 0.98%, respectively. Peroxide value, acid value, pH, TVB-N value and aerobic plate count were found to be highest in *W. attu* followed by *G. giuris* and *C. striatus*. Results of this study revealed that traditionally sun dried fish products were acceptable quality in terms of physico-chemical, microbiological and sensory aspects.

**Keywords:** Sun dried fishes; Food quality; Proximate composition analysis; Mineral content.

### Introduction

Fishes play an important roles in human diets as good sources of animal protein that also provide other important elements necessary for the maintenance of

healthy bodies (Ravichandran et al., 2012). Fish is an extremely perishable food item and quality losses occur very rapidly after harvest (Dewi et al., 2011; Musa et al., 2010; Khan and Khan, 2001) and require preservation. Several methods are followed

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over the world for preserving fish to extend its shelf life including drying, salting and smoking. Fish drying is an important method of fish preservation for most traditional fishing communities in tropical countries like Bangladesh (Balachandran, 2001).

Dried fish (Shutki in Bengali) is one of the popular food items in Bangladesh. It preserves the quality for an extended time and offers several advantages such as insignificant alterations and minimum deterioration in the product. About 20% of the artesian catch is sun dried and consumed in the domestic market (Begum et al., 2012). The significant amount of dried fishes (approx. 622 metric ton) were exported from Bangladesh and earned 3.13 million USD as foreign currency (DoF, 2011). Recently, Bangladeshi dried fish and fishery products are decreasing tendency of export market demand for the use of low quality raw fish for drying, traditional drying practices, unhygienic and improper sanitation facilities and random use of unauthorized chemicals and insecticides at the different stages of drying process of fish (Hasan et al., 2016).

Sun drying is one of the most important low-cost fish preservation methods not only in Bangladesh but also in many areas in the world. Dried fish is an important source of protein and other essential nutrients for the maintenance of a healthy body (Arannilewa et al., 2005). It is relished by many people of coastal, central and North-eastern districts of Bangladesh. Nutritional quality of dried fishery product remains intact - sometimes retains higher quality standards compared to fresh fish (as per unit weight). Moreover, the special flavor is highly relished by different ethnic people. The main principle of fish drying is to stop the progress of muscle enzymatic activity and microbial growth by reducing the water activity of fish (Humayun, 1995).

However, it is suggested that the quality of the traditionally sun dried fishes found in the local market are not satisfactory for human consumption (Reza

et al., 2005). One of the major problems associated with the traditional sun-drying of fish is an infestation of the products by the blow fly and beetle larvae. Other problems markedly evident with dried fish are the contamination during different stages of handling and processing and the indiscriminate use of various types of pesticides (Nowsad, 2005).

Therefore, the present study was aimed to compare the quality of three sun dried fish species such as Boal *Wallago attu* Bloch & Schneider, 1801 (Siluriformes: Siluridae), Shol *Channa striatus* (Bloch, 1793) (Perciformes: Channidae) and Bele *Glossogobius giuris* (F. Hamilton, 1822) (Perciformes: Gobiidae) by sensory, physical, chemical and microbiological analysis.

## Methods and materials

### Collection of samples

Sun-dried fishes such as *W. attu* (Bengali-Boal), *C. striatus* (Bengali-Shol) and *G. giuris* (Bengali-Bele) were collected from Kawran Bazar Fish Market, Dhaka. Dried fish samples were brought by tightly packing in polyethylene bags and stored at room temperature (24-29 °C) until further analysis. The experimental work of this study was carried out at the laboratory of Department of Fisheries Technology, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh.

### Physical characteristics

Physical characteristics such as color, odor, texture and insect infestation of the traditionally sun-dried fishes were examined by sensory test on the basis of the method described by Roy (2013) with the help of five member panels of experts.

### Proximate composition analysis

The compositions of moisture, protein, crude lipid and ash content of dried fish were analyzed in triplicate according to the standard procedure given in Association of Official Analytical Chemists (AOAC, 1995).

### Determination of lipid oxidation

To analyze the degree of lipid oxidation of dried fish, lipids was extracted and then peroxide value and the acid value was determined.

### Extraction of lipid

Total lipid was extracted from dried fish samples with a solvent combination of chloroform: methanol: distilled water according to the method of Bligh and Dyer (1959) with slight modification making those final ratios 10:5:3, v/v/v. Then the extracted lipid was dissolved in chloroform and stored at -20 °C until further analysis.

### Determination of peroxide value

Peroxide value was determined according to the standard procedure given in AOAC (1995). Lipid (0.5 g) was poured in a conical flask and mixed with 30 mL of acetic acid and chloroform solution (ratio 3:2). Then 0.5 mL of saturated potassium iodide was added to it. The mixture was kept in the dark for about 10 min, and then 30 mL of distilled water and 0.5 mL of freshly prepared 1% starch were added. After shaking, the samples were titrated with 0.01 N sodium thiosulfate. The peroxide value was expressed as meq/kg of lipid.

### Determination of acid value

Acid value was analyzed according to the method of AOAC (1995). Lipid (0.5 g) was dissolved in a mixture of 100 mL of ethanol and diethyl ether (1:1; v/v) and titrated with 0.01 N potassium hydroxide. Phenolphthalein was used as an indicator. The results were expressed as mg KOH/g lipid.

### Determination of pH

About 10 g of sample was weighed in a beaker using electronic balance. Then the sample was homogenized using tissue homogenizer with 10 volumes of distilled water and the pH was measured by a pH meter.

### Determination of water reconstitution behavior

About 8-10 g of sample from individual dried fish was taken and weighted by analytical balance and then immersed into water at room temperature (24-29 °C), 40 °C and 60 °C. The dried fish sample was soaked into water for 60 min. Any loose muscle that attached to sample was removed before dipping into water. The dried fish sample was removed from the water at every 15 minutes interval and the surface water was removed with blotting paper and reweighted each sample by analytical balance. The percentage of water uptake in rehydrated fish samples was calculated as follows:

$$\text{Water reconstitution (\%)} = \frac{(W_r - W_i)}{W_i} \times 100$$

Where,  $W_i$  = Initial weight of the dried fish  
 $W_r$  = Weight of dried fish after water absorption

### Determination of TVB-N

Total volatile base nitrogen (TVB-N) was estimated according to the method of Antonacopoulos and Vyncke (1989).

### Determination of microbial load

In order to determine the microbial load of the sun-dried samples, aerobic plate count was done by spread plate count method. Physiological saline (0.85% NaCl) and plate count agar of commercial preparations were prepared in the laboratory as per the method is given in Cowan and Steel's Manual for the Identification of Medical Bacteria (Barrow and Feltheam, 1993). Plate count agar (Hi media, India) was used in this experiment.

### Statistical analysis

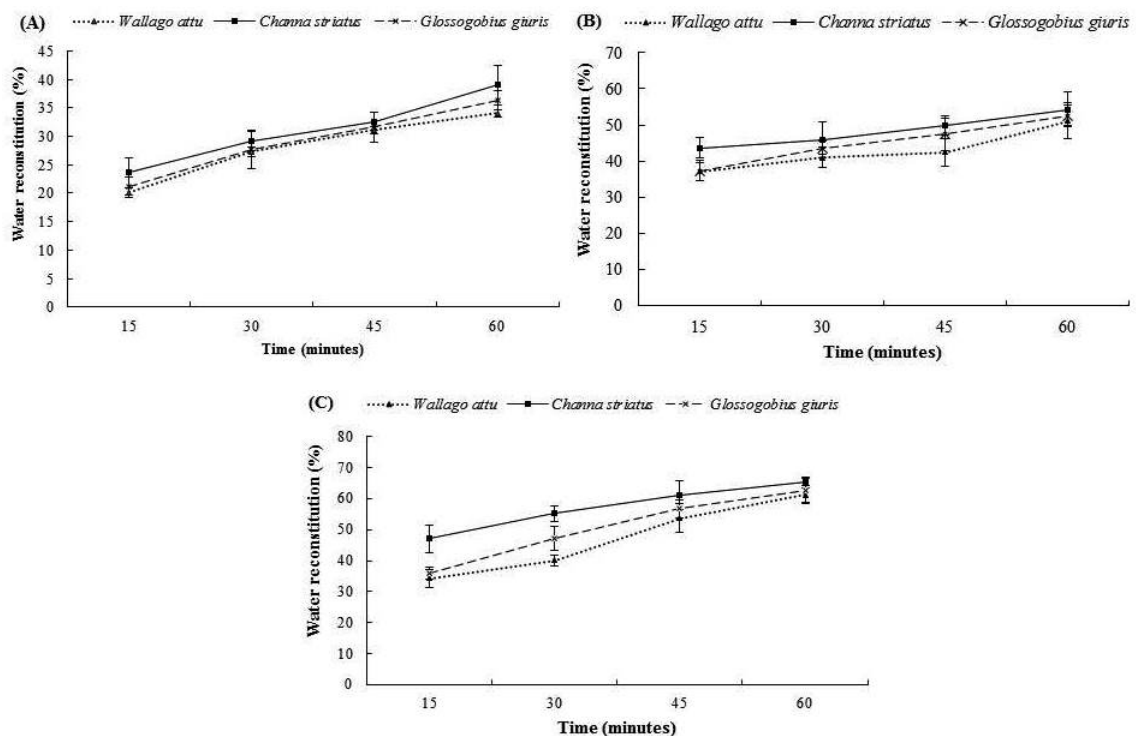
For each measurement, analyses were repeated 3 to 5 times, data were pooled, and the mean and standard deviation were determined. Statistical analysis was performed using Microsoft Office Excel 2007.

## Results and discussion

### Water reconstitution of dried fish products

The water reconstitution of dried fish products are presented in Figure 1. Generally, water holding capacity of dried fish products are increased with the increase of water temperature and soaking time. In this study, *W. attu* was shown to hold 37.07% moisture after 60 min at room temperature, whereas *C. striatus* and *G. giuris* dried products were shown to have 39.01% and 36.30%, respectively. Similar trend was also observed when dried fish were soaked at 40 °C and 60 °C for 60 min. Overall, *C. striatus* dried fish

were rehydrated more rapidly than *G. giuris* and *W. attu* dried fish products. And the rehydration ability of dried fish products was depended on elevated soaking temperature and extended period of time. It has been reported that there was a positive relationship between rehydration ability and physical properties of dried fish products (Reza et al., 2005). This might be due to the fact that increased temperature of water opens the internal structure of fish muscle which maximizes the scope of rapid rehydration (Brennan et al., 1990; Tunde-Akintunde, 2008). Moreover, rehydration ability of dried fish products depends on the variation of species besides time and temperature (Nurullah, 2005; Tunde-Akintunde, 2008).

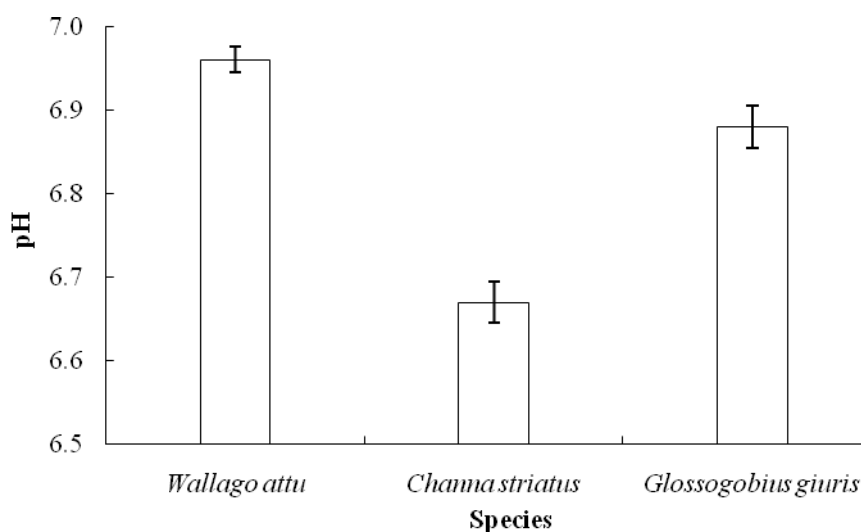


**Figure 1.** Water reconstitution behaviour of sun dried *W. attu*, *C. striatus* and *G. giuris* at (A) room temperature, (B) 40 °C, and (C) 60 °C.

### pH value of sun dried fishes

The pH values of three sun dried fish products are shown in Figure 2. The pH values were ranged from 6.67 to 6.96. The highest pH value was found in *W. attu* while the lowest was observed in *C. striatus*. The lowest pH values of dried

products may enhance microbial inhibition and contribute to extend the shelf life of dried fish by inhibiting the activity of the endogenous proteases. On the other hand, an increase in pH indicates the loss of quality in fishes (Farid et al., 2014).



**Figure 2.** The pH values of sun dried fish products

### Proximate composition of sun dried fish products

Proximate composition of dried *W. attu*, *C. striatus* and *G. giuris* are demonstrated in Table 1. The moisture content of the dried fishes was observed in the range of 18.75%-22.70% with the highest value obtained from *W. attu* and the lowest value from *C. striatus* fish. Flowra and Tumpa (2012) reported that the moisture content of five different dried fishes ranged between 12.13% and 18.18%. It is well known that no microbe could grow in dried fish products when moisture content < 15% (Frazier and Westhoff, 1978). The variation of moisture content among these dried fishes may occur due to improper storage, improper drying, unawareness of processors etc. According to Kamruzzaman (1992), when salt is added

to the fish before drying, less water needs to be removed to achieve the same effect, and the product with a water content of 35%-45%, depending on amount of salt present, is often dry enough to inhibit the growth of molds and bacteria under most climatic condition. It has been reported that the water activity increases with the water absorption from environment, which enhances the microbial growth and reduces the loss of nutrient and shelf life of dried products (Nowsad, 2005). Sometimes fish processors keep comparatively higher moisture content in the dried fish products to gain more weight for economic benefit (Nowsad, 2003).

The crude protein content ranged from 61.85% to 66.44% with the highest value in *C. striatus* and the lowest in *W. attu* (Table 1). It was found that the

protein content of five different dried fishes varied from 28.20% to 51.19% (Flowra and Tumpa, 2012). Our result is more or less similar with the previous study conducted by Azam et al. (2003) who found that the protein values ranged from 40.69% to 66.52% in 14 species of dried fishes.

Lipid content was ranged from 5.98% to 6.81% with the highest lipid content in *C. striatus* and the lowest in *G. giuris* (Table 1). Flowra and Tumpa (2012) reported that the lipid content of five dried fish species was ranged between

5.38% and 15.86%. Hussain et al. (1992) also reported that 3.7% to 17.8% lipid in 23 sun-dried fish species, which is similar to our study.

Ash content was found in the range of 6.49% to 7.83% with the highest value in *G. giuris* and the lowest value from *C. striatus* (Table 1). This is perhaps due to contamination with sand and filth during drying and storage in different marketing chains. Flowra and Tumpa (2012) observed that the ash content of different dried fishes was varied from 10.78% to 15.67%.

**Table 1.** Proximate composition (%) of dried *W. attu*, *C. striatus* and *G. giuris*<sup>1</sup>.

Samples	Moisture	Protein	Lipid	Ash
<i>W. attu</i>	22.70 ± 0.45	61.85 ± 0.99 (80.01 ± 1.28)*	6.21 ± 0.93 (8.03 ± 1.16)	6.79 ± 1.11 (8.78 ± 1.39)
<i>C. striatus</i>	18.75 ± 0.58	66.44 ± 1.02 (81.78 ± 1.25)	6.81 ± 0.72 (8.38 ± 0.87)	6.49 ± 1.29 (7.99 ± 1.53)
<i>G. giuris</i>	21.93 ± 0.54	62.83 ± 0.87 (80.48 ± 1.03)	5.98 ± 0.55 (7.66 ± 0.73)	7.83 ± 0.98 (10.03 ± 1.11)

<sup>1</sup>Each value is expressed as mean ± SD (n = 3).

\*Percent dry matter basis.

#### TVB-N value of sun dried fishes

The TVB-N values of different sun dried fish products are shown in Table 2. The TVB-N values were 28.39 mg/100 g, 32.07 mg/100 g and 34.21 mg/100 g in *C. striatus*, *G. giuris* and *W. attu*, respectively. The highest TVB-N value was found in *G. giuris* while the lowest value was observed in *C. striatus*. The TVB-N values of some traditionally sun dried fishes were ranging from 28.9-46.32 mg/100g (Sen et al., 1961). The TVB-N values of all the samples were found to be lower than the recommended value (100-200 mg/100 g) of different salted and dried fish products (Connell, 1995).

#### Lipid oxidation of sun dried fishes

The peroxide value of dried fishes was ranged from 16.27 ± 0.63 meq/kg to 19.12 ± 0.82 meq/kg lipid (Table 2). The peroxide values observed in this study were within acceptable limits (PV ≤ 20 meq/kg fish lipid) (Connell, 1995). It has been

reported that peroxide value of herring (*Clupea pallasii*) lipids (5.52-11.86 meq/kg) increased significantly during the drying period (Shah et al., 2009). In addition to peroxide value, the acid value was measured to determine the degree of lipid hydrolysis in dried fish products. The acid values of dried fishes were ranged from 15.03 ± 0.77 mg KOH/g to 18.64 ± 0.82 mg KOH/g of lipid in dried fish products. The lower acid values indicate the better quality of a product. Our result is more or less similar to that reported by Shah et al. (2009) who found that the acid value of dried herring fillet ranged between 11.20 and 18.94 mg KOH/g of lipid. An increased amount of acid value of dried fish products might be due to release of free fatty acids by lipid hydrolysis. Lipid peroxidation, corresponding to the oxidative deterioration of polyunsaturated fatty acids in fish muscle, leads to the production of off-flavor and off-odor, there by shortening the shelf-life of food (Ramanathan and Das, 1992).

**Table 2.** Acid value, peroxide value and TVB-N of sun dried *W. attu*, *C. striatus* and *G. giuris*.

Samples	Acid value (mg KOH/g lipid)	Peroxide value (meq/kg lipid)	TVB-N (mg/100 g)
<i>W. attu</i>	16.23±0.91	19.12±0.82	34.21±0.79
<i>C. striatus</i>	15.03±0.77	16.27±0.63	28.39±0.68
<i>G. giuris</i>	18.64±0.82	16.31±0.84	32.07±0.94

### Microbiological load of dried fish products

Aerobic plate count (APC) of dried fish products were ranged from  $4.76 \times 10^5$  to  $2.11 \times 10^6$  CFU/g (Table 3).

**Table 3.** Aerobic plate count (CFU/g) of sun dried *W. attu*, *C. striatus* and *G. giuris*.

Samples	Aerobic Plate Count (CFU/g)
<i>W. attu</i>	$2.11 \times 10^6$
<i>C. striatus</i>	$4.76 \times 10^5$
<i>G. giuris</i>	$6.33 \times 10^5$

The highest APC was found in *W. attu* probably due to the fact that higher moisture content and poor hygienic condition compared with *C. striatus* and *G. giuris*. The results obtained from the sun dried products of this study is more or less similar to those of some marine dried products produced in solar tunnel dryers where APC of dried Ribbon fish, Bombay

Duck, Big-eye Tuna, Silver Jew fish and Chinese Pomfret were in the range of 3.27 to 4.49 log CFU/g (Reza et al., 2008).

### Sensory characteristics of dried fish products

Sensory characteristics of sun dried *W. attu*, *C. striatus* and *G. giuris* are depicted in Table 4. The sensory characteristics such as color, odor, texture, and insect infestation showed that the *C. striatus* was good in quality, while the *W. attu* and *G. giuris* had decreased the quality. *W. attu* and *G. giuris* fish lost their color, odor and texture from their original characteristics compared with *C. striatus*. But all samples were free from insect infestation and broken pieces. Some of the samples contained high quantity of broken pieces, which might be the result of using poor quality raw material, excess drying or improper drying and handling or due to moisture reconstitution (Mansur et al., 2013).

**Table 4.** Sensory characteristics of sun dried *W. attu*, *C. striatus* and *G. giuris*.

Samples	Color	Odor	Texture	Insect Infestation	Overall Quality
<i>W. attu</i>	Brownish	Good	Loss of firmness	Nil	Acceptable
<i>C. striatus</i>	Slightly Darkish	Characteristics	Firm and flexible	Nil	Good
<i>G. giuris</i>	Whitish	Good	Firm and flexible	Slightly	Acceptable

### Conclusion

Results of this study demonstrated that *C. striatus* showed good in sensory quality than *W. attu* and *G. giuris*. Among the dried fish products, *C. striatus* indicates better quality through chemical evaluation such as proximate composition, lipid

oxidation (peroxide value and acid value) and TVB-N values. In the case of microbiological analysis, similar trends were also observed in *C. striatus*. Thus, it can be concluded that *C. striatus* proved superior in overall quality than *W. attu* and *G. giuris*.

## Conflict of interest statement

Authors declare that they have no conflict of interests.

## References

- Antonocoupoulos, N.; Vyncke, W. Determination of volatile basic nitrogen in fish: A third collaborative study by the West European Fish Technologists' Association (WEFTA). **Zeitschrift für Lebensmittel-Untersuchung und Forschung**, v. 189, p. 309-316, 1989. <https://doi.org/10.1007/BF01683206>
- AOAC - Association of Official Analytical Chemists. **Official methods of analysis**. 16 ed. Virginia, USA: Association of Official Analytical Chemists, 1995.
- Arannilewa, S. T.; Salawu, S. O.; Sorungbe, A. A.; Ola-Salawu, B. B. Effect of frozen period on the chemical, microbiological and sensory quality of frozen tilapia fish (*Sarotherodon galiaenus*). **African Journal of Biotechnology**, v. 4, no. 8, p. 852-855, 2005. Available from: <[http://www.academicjournals.org/article/article1380097697\\_Arannilewa et al.pdf](http://www.academicjournals.org/article/article1380097697_Arannilewa%20et%20al.pdf)>. Accessed on: May 23, 2017
- Azam, K.; Basher, M. Z.; Asaduzzaman, M.; Hossain, M. H.; Ali, M. Y. Biochemical quality assessment of fourteen selected dried fishes. **University Journal of Zoology, Rajshahi University**, v. 22, p. 23-26, 2003.
- Balachandran, K. K. **Post-harvest technology of fish and fish products**. Delhi: Daya Publishing House, 2001.
- Barraw, G. L.; Feltham, R. K. A. **Cown and steet's manual for the identification of medical bacteria**. 2. ed. Cambridge: Cambridge University Press, 1993.
- Begum, M.; Akter, T.; Minar, M. H. Effect of salt and garlicon the quality and microbial content of smoked catfish (*Pangasianodon hypophthalmus*). **International Journal of Bio-Resource and Stress Management**, v. 3, no. 4, p. 464-467, 2012.
- Bligh, E. G.; Dyer, W. J. A rapid method of total lipid extraction and purification. **Canadian Journal of Biochemistry and Physiology**, v. 37, no. 8, p. 911-917, 1959. <https://doi.org/10.1139/o59-099>
- Brennan, J. G.; Butters, J. R.; Cowell, N. D.; Lilly, A. E. V. **Food engineering operations**. 3. ed. London: Applied Science, 1990.
- Connell, J. J. **Control of fish quality**. 4 ed. Oxford: Fishing News Books, 1995.
- Dewi, R. S.; Nurul, H.; Ahmad, R. Changes in the physico-chemical properties, microstructure and sensory charecterstics of shark dendeng using different drying methods. **American Journal of Food Technology**, v. 6, p. 149-157, 2011. <http://dx.doi.org/10.3923/ajft.2011.149.157>
- DoF - Department of Fisheries. **Fish fortnight publication**. Dhaka, Bangladesh: Department of Fisheries, Ministry of Fisheries and Livestock, 2011.
- Farid, F. B.; Latifa, G. A.; Nahid, M. N.; Begum, M. Comparison of the changes in physico-chemical characteristics of dry salted snake-head shoal (*Channa striatus* Bloch, 1801) and taki (*Channa punctatus* Bloch, 1793) at room temperature (27 °C to 31 °C). **Research Journal of Animal, Veterinary and Fishery Sciences**, v. 2, no. 9, p. 18-23, 2014. Available from: <<http://www.isca.in/AVFS/Archive/v2/i9/4.ISCA-RJAVFS-2014-037.pdf>>. Accessed on: May 23, 2017.
- Flowra, A. F.; Tumpa, S. A. Chemical composition of five selected dry fish species in Chalan beel, Bangladesh. **DAV International Journal of Sciences**, v. 1, no. 2, p. 157-160, 2012.
- Frazier, W. C.; Westhoff, D. C. **Microorganisms important in food microbiology**. 3. ed. New York: McGraw-Hill, 1978.
- Hasan, M. M.; Shikha, F. H.; Hossain, M. I.; Kamal, M.; Islam, M. N.; Wahab, M. A. Quality assessments of traditional, rotary and solar tunnel dried small indigenous fish products. **Bangladesh Journal of Fisheries Research**, v. 10, no. 1, p. 73-84, 2006. Available from: <[http://aquaticcommons.org/18868/1/BJFR10.1\\_073.pdf](http://aquaticcommons.org/18868/1/BJFR10.1_073.pdf)>. Accessed on: May 23, 2017.
- Humayun, N. M. **Studies on the improvement of traditional preservation method of fish drying to augment the quality and the shelf life of the product**. Mymensingh: Department of Fisheries Technology, Bangladesh Agricultural University, 1995. (M. Sc. Thesis).
- Hussain, M. M.; Karim, A.; Alam, Z.; Islam, M. S.; Khan, A.; Hossain, A. Effect of pre-treatment on the drying of Ghonia fish (*Labeo gonius*) in the open sun and in a solar tent. **Bangladesh Journal of Zoology**, v. 20, p. 231-238, 1992.
- Kamruzzaman, A. K. M. **Qualitative evaluation of some commercial dried fish products of Bangladesh**. Mymensingh: Department of Fisheries Technology,



- Bangladesh Agricultural University, 1992. (M. Sc. Thesis).
- Khan, M. A. A.; Khan, Y. S. A. Insects infestation and preventive measures in dry fish storage of Chittagong, Bangladesh. **Journal of Biological Sciences**, v. 1, p. 963-965, 2001. <http://dx.doi.org/10.3923/jbs.2001.963.965>
- Mansur, M. A.; Rahman, S.; Khan, M. N. A.; Reza, M. S.; Kamrunnahar, B.; Uga, S. Study on the quality and safety aspect of three sun-dried fish. **African Journal of Agricultural Research**, v. 8, no. 41, p. 5149-5155, 2013. Available from: <[http://www.academicjournals.org/article/article1382099189\\_Mansur et al.pdf](http://www.academicjournals.org/article/article1382099189_Mansur_et_al.pdf)>. Accessed on: May 23, 2017.
- Musa, U.; Hati, S. S.; Adamu, Y. I.; Mustapha, A. Pesticides residues in smoked fish samples from North-Eastern Nigeria. **Journal of Applied Sciences**, v. 10, p. 975-980, 2010. <http://dx.doi.org/10.3923/jas.2010.975.980>
- Newsad, A. K. M. **New method of drying fish in solar fish dryer**. Rome: Food and Agricultural Organization of the United Nations, 2003. (Empowerment of coastal fishing community project).
- Newsad, A. K. M. **Participatory training of trainers: a new approach applied in fish processing**. Bangladesh: Bangladesh Fisheries Research Forum, 2005.
- Nurullah, M. **Quality assessment and improvement of traditionally dried small indigenous fish of Bangladesh**. Mymensingh: Department of Fisheries Technology, Bangladesh Agricultural University, 2005. (Ph. D Thesis).
- Ramanathan, L.; Das, N. P. Studies on the control of lipid oxidation in ground fish by some polyphenolic natural products. **Journal of Agricultural and Food Chemistry**, v. 40, no. 1, p. 17-21, 1992. <https://doi.org/10.1021/jf00013a004>
- Ravichandran, S.; Joseph, F. R. S.; Kanagalakshmi, R.; Ramya, M. S. Variation in nutritive composition of two commercially important marine fin fishes. **International Journal of Zoological Research**, v. 8, p. 43-51, 2012. <https://doi.org/10.3923/ijzr.2012.43.51>
- Reza, M. S.; Bapary, M. A. J.; Azimuddin, K. M.; Nurullah, M.; Kamal, M. Studies on the traditional drying activities of commercially important marine fishes of Bangladesh. **Pakistan Journal of Biological Sciences**, v. 8, no. 9, p. 1303-1310, 2005. <http://dx.doi.org/10.3923/pjbs.2005.1303.1310>
- Reza, M. S.; Bapary, M. A. J.; Islam, M. N.; Kamal, M. Optimization of marine fish drying using solar tunnel dryer. **Journal Food Processing and Preservation**, v. 33, p. 47-59, 2008. <https://doi.org/10.1111/j.1745-4549.2008.00236.x>
- Roy, V. C. **Improvement of food quality of dried Bombay duck (*Harpodon nehereus*) product using salt and herbal substances**. Mymensingh: Department of Fisheries Technology, Bangladesh Agricultural University, 2013. (M. Sc. Thesis).
- Sen, D. P.; Anandaswamy, B.; Iyenger, N. V. R.; Lahiry, N. L. Studies on the storage characteristics and packaging of the sun-dried salted Mackerel. **Food Sciences**, v. 10, no. 5, p. 148-156, 1961.
- Shah, A. K. M. A.; Tokunaga, C.; Kurihara, H.; Takahashi, K. Changes in lipids and their contribution to the taste of Migaki-nishin (dried herring fillet) during drying. **Food Chemistry**, v. 115, no. 3, p. 1011-1018, 2009. <https://doi.org/10.1016/j.foodchem.2009.01.023>
- Tunde-Akintunde, T. Y. Effect of soaking water temperature and time on some rehydration characteristics and nutrient loss in dried bell pepper. **Agricultural Engineering International: the CIGR Ejournal**, v. 10, p. 8-13, 2008. Available from: <<http://www.cigrjournal.org/index.php/Ejournal/article/view/1225/1080>>. Accessed on: May 23, 2017.