A SEMINAR PAPER ON

QUALITY AND SAFETY ASPECTS OF DRIED FISHERY PRODUCTS AVAILABLE IN BANGLADESH

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SUBMITTED TO:

Course Instructors

1. **Dr. Md. Mizanur Rahman**
   Professor
   BSMRAU
2. **Dr. A. K. M. Aminul Islam**
   Professor
   BSMRAU
3. **Dr. Md. Rafiqul Islam**
   Professor
   BSMRAU
4. **Dr. Dinesh Chandra Shaha**
   Assistant Professor
   BSMRAU

Major Professor

Dr. A.K.M. Azad Shah
Professor
Department of Fisheries Technology
BSMRAU

SUBMITTED BY

Ilias Ebne Kabir
MS Student
Reg. No.: 13-05-3042
Department of Fisheries Technology

BANGABANDHU SHEIKH MUJIBUR RAHMAN AGRICULTURAL UNIVERSITY

SALNA, GAZIPUR-1706

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ON

QUALITY AND SAFETY ASPECTS OF DRIED FISHERY PRODUCTS AVAILABLE IN BANGLADESH[1]

BY

ILIAS EBNE KABIR[2]

ABSTRACT

The study was carried out to know the quality and safety aspects of different dried freshwater and marine water fishery products available in Bangladesh. The quality of freshwater dried fish (*Wallagu attu, Channa striatus, Glossogobius giuris, Amblypharyngodon mola*, *Osteobrama cotio cotio*, *Barbides sarana*, *Pseudotropius atherinoides*, *Chela cachius*, *Gudusia chapra* and *Mystus vittatus*) and marine water dried fish (*Johnius argentatus, Harpodon nehereus, Scomberomorus gottatus, Stromateus chinensis* and *Trichiurus haumela*) products were studied. In term of physical aspects, freshwater fish *W. attu*, *G. giuris* and marine water fish Ribbion, Chinese Pomfret, Bombay duck, Big-eye tuna, Silver jew fish were in acceptable limit. In the chemical analysis, all the dried products are excellent in quality which might be gradually decrease with the storage time. The microbial load of both fresh and marine water dried products was in recommended level (7×10^{10} CFU/g). The overall quality of these dried products was gradually decrease with the increase of storage period due to reabsorption of moisture, decreasing pH with increasing microbial load, high oxidation of the dried product etc. This study was easily concluded that proper drying technique and appropriate storage condition can reduce the chances of quality loss and that is very much essential to maintain the quality and safety of the dried fishery products available in Bangladesh.

Keywords: Freshwater fish, Marine water fish, Organoleptic, Chemical composition and Microbial load.

[1]Paper presented at Graduate Seminar Course FIT 598

[2]MS Student, Department of Fisheries Technology, BSMRAU, Gazipur-1706

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CHAPTER I

INTRODUCTION

Fish is one of the most vital sources of animal protein available, and has been widely regarded as a good protein source and other essential nutrients for the maintenance of a healthy body (Arannilewa et al., 2005) of which a remarkable part comes from dried fishes. Dried fish is a very popular food item in Bangladesh. The product is easily transportable, marketable, storable, and has good market demand in the country or abroad. Fish supplements about 60% of Bangladeshi people's daily animal protein intake (DoF, 2016). The fisheries sector plays a very important role in the national economy, contributing 3.69% to the Gross Domestic Product (GDP) of the country and 22.60% to the agricultural GDP (FRSS, 2016). A sizeable quantity of fish is preserved by sun drying in Bangladesh from freshwater fish as well as from marine fish. Bangladesh earns a huge amount of foreign currency by exporting dried fish every year.

Dried fish is a very favorite food item among the people of South-east Asian countries and has a good market demand. It is low cost dietary protein source and used as a substitute of fish at the scarcity of fresh fish in Bangladesh (Khan and Khan, 2001) and many other countries. These products contain most of the important nutritional components and serves as a source of energy for human beings (Koffi-Nevry et al., 2011; Sutharshiny and Sivashanthini, 2011). Fish is rich in vitamin and minerals for both young and old age consumers (Edem, 2009; Koffi-Nevry et al., 2011; Moghaddam et al., 2007). Interestingly, many people do not like to eat some marine fish species as fresh but they like to eat dried fish of these species. Moreover, dried fish is available throughout the year because it can be stored for longer time without any preservatives.

Drying is one of the most important methods of preserving fish throughout the world. It is still a vital fish processing technique in the developing countries of the world. A major problem associated with sun drying of fish in Bangladesh is the infestation of the product by fly and insect larvae during drying and storage (Ahmed et al., 1978). To minimize the problems, netting and neem leaves are used. In general, bacteriological problem associated with quality loss is not significant in properly dried and well-packaged fish products. Mainly dried fish products are contaminated during different stages of handling and improper packaging. Dried fish products stored for longer period become brownish yellow or brown color, which indicates varying degree of spoilage (Connell, 1957). Rao et al. (1962) found that, a relative humidity of over 70% was conductive to mould attack. The consumer preference for dried fish products is not only because of their traditionally desirable taste and flavor, but also their high content of omega-3 polyunsaturated fatty acids especially in fish lipids, which have various health benefits for human (Li et al., 2003).

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; Saha, 1999; Reza et al., 2005). The major problems associated with sun drying of fish are infestation of the products by the fly and insect larvae during drying and storage, contaminants and spoilage. The quantitative losses through spoilage and insect attack on dried fish have been estimated to 10–35% in the marine areas (Doe et al., 1977; Ahmed et al., 1978). In Bangladesh, the traditional open air drying method using sun and wind has been practiced by the fishermen since ancient times to prepare such product. However, the dried fish produced by the traditional method are not safe for human consumption due to high risk of insect infestation and indiscriminate use of various types of insecticides (Bhuiyan et al., 2008). Moreover, the development of lipid oxidation often limits the possibilities for storage and processing of the dried fish products (Undeland et al., 1999). Intake of such highly oxidized products may cause adverse effects on the human body such as aging, heart disease, cancer, and brain dysfunction (Kinsella, 1987).

There are about 240 freshwater fish species are found in Bangladesh. Among them, most of the species are Small Indigenous Species (SIS) like *Amblypharyngodon mola* (mola), *Osteobrama cotio cotio* (dhela), *Barbides sarana* (puti), *Pseudotropius atherinoides* (batashi), *Gudusia chapra* (chapila) and *Mystus vittatus* (Tengra) are important dried fish products in our country and people consume huge amount of those products due to its characteristics taste, flavor and low price. Besides, there are some marine fishes like Silver jew fish, Bombay duck, Big-eye tuna, Chinese pomfret, Ribbon fish etc. are also some important dried fish products in our country. The present study was therefore undertaken based on the above premise and the following were its main objectives:

1) To assess the quality of the dried freshwater and marine fishery products available in Bangladesh, and
2) To discuss the safety and quality aspects of dried freshwater and marine fishery products available in Bangladesh.

CHAPTER II

MATERIALS AND METHODS

This seminar paper is exclusively a review paper. It has been prepared by reviewing the various articles published in different Books, Proceedings, Abstracts, Review papers, Journals, MS thesis, Ph.D. Dissertation etc. available in the library of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, including Bangladesh Fish Research Institute, Bangladesh Fisheries Development Corporation, Department of Fisheries DoF), etc. or anywhere else. I prepared this paper in consultation with my learned major professor, and other concerned experts. The necessary thoughts, ideas, facts and findings has been collected through internet searching and incorporated with the body of the seminar. In addition to that constructive and valuable suggestions of the experts were included, as and when necessary, in preparing this paper. Mostly secondary data have been adopted.

CHAPTER III

REVIEW OF MAJOR FINDINGS AND DISCUSSION

Comparative study of quality aspects of some sun dried fishes in Bangladesh

Organoleptic quality evaluation

Physical characteristics such as color, odor, texture, broken pieces and insect infestation of the traditionally sun-dried fishes were examined by organoleptic/sensory test on the basis of the method described by Roy (2013) (Table 1). Representative whole sample of dried fish products were taken on a tray to assess the physical characteristics by a five member panels of experts.

Table 1. Characteristic score for determining organoleptic quality of dried fishes during storage

Score	Description	Comment on quality
1. Score for color		
1 to 2.99	Characteristic color for every treatment	Excellent
3 to 5.99	Slightly brownish/whitish/yellowish	Average
6 to 7.99	Brownish/Fade	Moderately unacceptable
8 to 10	Darkish color	Highly unacceptable
2. Score for odor		
1 to 2.99	Characteristic fishy odor	Excellent
3 to 5.99	Slight decrease of dry fish odor	Good
6 to 7.99	Slightly rancid	Average
8 to 10	Prominence of herbal odor/absence of dry fish/rancid	Poor in quality and unacceptable
3. Score for texture		
1 to 2.99	Firm and flexible	Excellent
3 to 5.99	Some loss of firmness and elasticity	Average
6 to 7.99	Soft in texture	Poor in quality and unacceptable
8 to 10	Fragile/Fragmented	Unacceptable
4. Score for infestation		
1 to 2.99	No infestation	Excellent
3 to 5.99	Few insect infestation	Average
6 to 7.99	Moderately insect infestation	Poor in quality and unacceptable
8 to 10	Heavily insect infestation	Unacceptable

Source: Roy (2013)

Sensory characteristics of dried freshwater fish products

Sensory characteristics of sun dried *Wallagu attu*, *Channa striatus* and *Glossogobius giuris* are depicted in Table 2. The sensory characteristics such as color, odor, texture, and insect infestation showed that the *C. straitus* 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. straitus*. But all samples were almost 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).

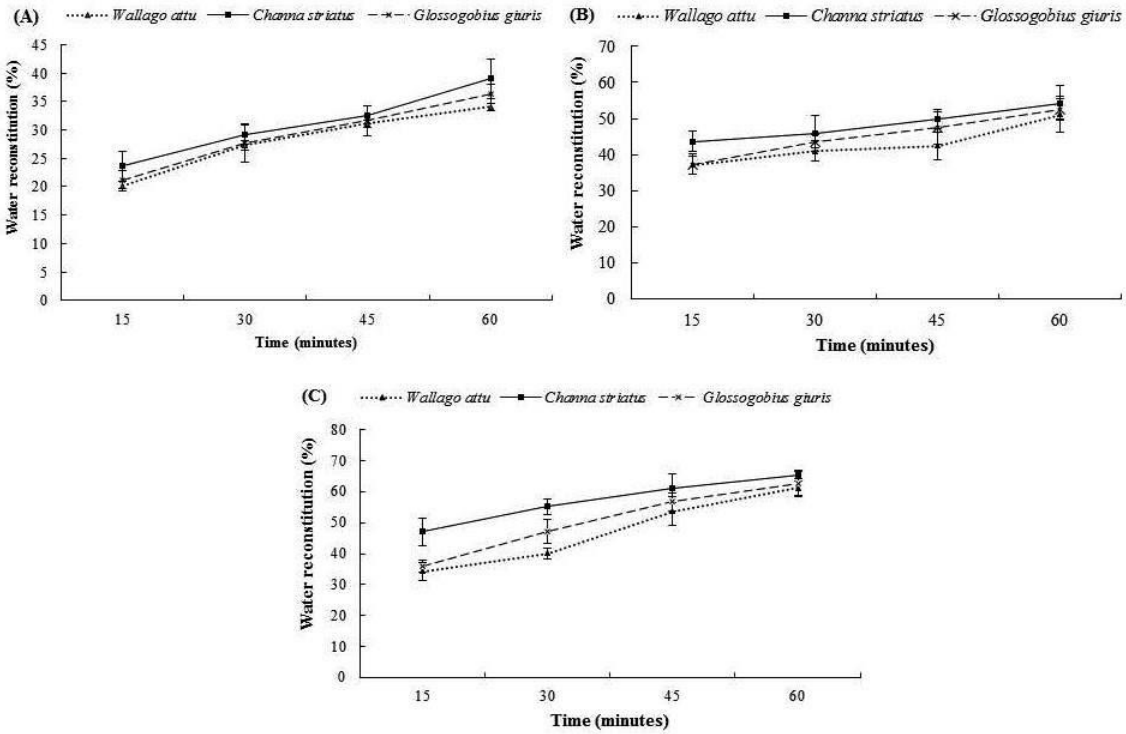
Table 2. Sensory characteristics of sun dried freshwater *W. attu*, *C. striatus* and *G. giuris*

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

Source: Majumdar et al. (2017)

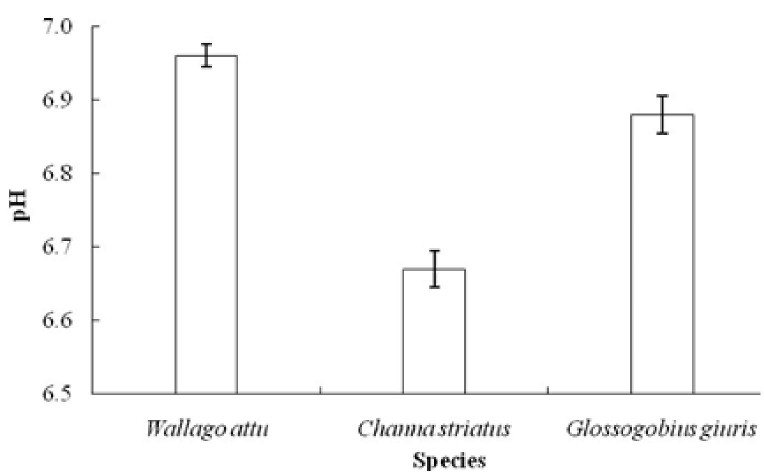
Water reconstitution of dried fish products

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 ºC and 60 ºC for 60 min. Overall, *C. striatus* dried fish products 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).



Source: Majumdar et al. (2017)

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



Source: Majumdar et al. (2017)

Figure 2. pH value of sun dried freshwater *W. attu*, *C. striatus* and *G. giuris*.

pH value of sun dried freshwater 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 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).

Proximate composition of sun dried freshwater fish products

Proximate composition of dried *W. attu, C. striatus* and *G. giuris* are demonstrated in Table 3. The moisture content of the dried fishes was observed in the range of 18.75% to 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%. The variation of moisture content among these dried fishes may occur due to improper storage, improper drying, unawareness of processors etc. 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).

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 3). It was found that the protein content of five different dried fishes varied from 28.20% to 51.19% (Flowra and Tumpa, 2012).

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 3). Flowra and Tumpa (2012) reported that the lipid content of five dried fish species was ranged between 5.38% and 15.86%.

Table 3. Proximate composition (%) of dried freshwater *W. attu*, *C. striatus* and *G. giuris*[1]

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

Source: Majumdar et al. (2017)

[1]Each value is expressed as mean ± SD (n = 3).

*Percent dry matter basis.

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 3). 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%.

Total Volatile Base Nitrogen (TVB-N) value of sun dried freshwater fishes

The TVB-N values of different sun dried fish products are shown in Table 4. 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 *W. attu* while the lowest value was observed in *C. striatus*. 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 freshwater fishes

The Peroxide Value (PV) of dried fishes was ranged from 16.27±0.63 meq/kg to 19.12±0.82 meq/kg lipid (Table 4). The peroxide values observed in this study were within acceptable limit (PV ≤ 20 meq/kg fish lipid) (Connell, 1995). The highest peroxide value was found in *W. attu* while the lowest value was observed in *C. striatus*. It has been reported that peroxide value of herring (*Clupea pallasii*) lipids (5.5211.86 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.

Table 4. 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)
W. attu	16.23±0.91	19.12±0.82	34.21±0.79
C. striatus	15.03±0.77	16.27±0.63	28.39±0.68
G. giuris	18.64±0.82	16.31±0.84	32.07±0.94

Source: Majumdar et al. (2017)

The highest acid value was found in *G. giuris* while the lowest value was observed in *C. striatus*. 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.

Microbiological load of dried fish freshwater products

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

Table 5. Aerobic plate count (CFU/g) of sun dried freshwater *W. attu*, *C. striatus* and *G. giuris*

Samples	Aerobic Plate Count (CFU/g)
W. attu	2.11×10^6
C. striatus	4.76×10^5
G. giuris	6.33×10^5

Source: Majumdar et al. (2017)

Quality assessments of sun dried SIS (Small Indigenous Fish Species) products

Proximate composition of Small Indigenous Species (SIS)

Chemical composition i.e. moisture, protein, lipid and ash of the s traditionally dried products is shown in Table 6. The moisture content of the products ranged from 23.26 to 26.42% with the lowest in dhela and the highest in tengra. It is to be noted that there is a tendency in our country for fish processors and retailers sometimes allow more moisture in dried fish products to gain weight for economic benefit. The other reason is that the died products used for selling in the wholesale and retail market and during storage normally are not kept in suitable packaging material. In a tropical country like Bangladesh where relative humidity is always high, there is a chance of moisture uptake from the environment. Excessive moisture uptake increases the water activity which facilitates the growth of micro-organisms, loss of nutrients and reduction shelf-life of dried products.

The protein contents varied from 48.60 to 52.20% on fresh weight basis. The range of protein contents on moisture free basis was 66.50 to 73.54% with highest value obtained in chapila and lowest value in mola. It is possible that the total nitrogen content in most dried samples obtained from various market sources increased due to the growth of microorganisms and release of metabolites during drying.

Table 6. Proximate composition of Small Indigenous Species

Samples	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Amblypharyngodon mola (mola)	26.02	49.20	10.76	19.32
		(66.50)*	(14.54)	(26.11)
Osteobrama cotio cotio (dhela)	23.26	52.20	9.50	16.00
		(68.02)	(12.37)	(20.84)
Barbides sarana (puti)	24.14	50.38	11.52	14.00
		(66.99)	(15.31)	(18.61)
Pseudotropius atherinoides (batashi)	26.26	48.60	8.40	17.80
		(68.45)	(22.43)	(23.98)
Mystus vittatus (tengra)	26.42	51.23	10.58	12.20
		(69.98)	(14.45)	(16.48)
Gudusia chapra (chapila)	26.24	51.48	9.21	13.45
		(73.54)	(21.39)	(19.21)

Source: Nurullah et al. (2006)

*Values within parenthesis indicate the results on dry weight basis

Lipid contents of dried SIS varied from 8.40 to 11.52% with the highest value found in puti and the lowest in batasi and on moisture free basis the lipid contents were in the range of 12.37 to 22.43% with the highest value found in batashi and the lowest in dhela. The lipid contents were reported to vary greatly even within the species according to age, sex, season, feeding habit and habitat (Stansby, 1962).

Ash contents of dried SIS varied from 12.20 to 19.32% with the highest value obtained in mola and the lowest in tengra on fresh fish basis. On the other hand, ash content in traditionally dried products on moisture free basis were in the range of 16.48 to 26.11% with the highest value obtained in mola and the lowest in tengra. Higher level of ash content in traditional dried SIS products might be associated with cross contamination during drying.

The results of proximate analysis of traditionally dried fish products indicate some variations in their composition. The most important and significant variation was observed in moisture and ash content. The results obtained on proximate composition are more or less similar as previously reported for freshwater fishes of this region (Qudrat-I-Khuda 1962, De 1967, Chaity 1992). Ahmed et al. (1979) reported that fishes dried by a solar drier contained higher percentage of protein and fat over the traditional sun dried products.

Water reconstitution properties of SIS

The results of the reconstitution properties of the dried products of each seven species after soaking in a series of water bath for time variation at 40 °C, 60 °C and 80 °C for maximum of 60 min are shown in Table 7, 8 and 9 respectively. Table 7 shows comparison of reconstitution behaviour traditionally dried SIS products at 40 °C. At 40 °C different reconstitution behaviour was observed with traditional dried SIS products where the reconstitution percentage was found relatively poor.

Table 7. Reconstitution behaviour of traditionally dried SIS products at 40 ºC shown as percentage of water holding capacity

Samples	**Reconstitution behaviour of traditionally dried SIS in % water holding capacity**			
	15 min.	**30 min.**	**45 min.**	**60 min.**
Amblypharyngodon mola (mola)	15.18	20.22	25.56	30.17
Osteobrama cotio cotio (dhela)	16.66	20.75	26.65	35.75
Barbides sarana (puti)	15.75	20.00	27.16	38.29
Pseudotropius atherinoides (batashi)	14.19	18.66	25.33	29.00
Mystus vittatus (tengra)	18.21	22.33	28.65	36.66
Gudusia chapra (chapila)	20.75	25.75	35.56	45.33
Phul chela	20.15	24.75	35.64	40.75

Source: Nurullah et al. (2006)

During 15 min soaking the reconstitution was in the range of 14.19 to 20.75% with the highest value determined with chapila and the lowest with batashi. Then reconstitution percentage increased with the lapse of socking time ranging between 29.00 and 45.33% after 60 min. of socking with maximum value in chapila and minimum in batashi.

Table 8 Shows the reconstitution of traditionally dried SIS products at 60 ºC. The reconstitution phenomenon indicates that the re-hydration increased as the socking temperature increased where maximum reconstitution of 21.66 to 45.25% in traditionally dried products was achieved during 15 min. socking at with the highest value in tengra and the lowest value in mola (Table 8).

Table 8. Reconstitution behaviour of traditionally dried SIS product at 60 ºC shown as percentage of water holding capacity

Samples	Reconstitution behaviour of traditionally dried SIS in % water holding capacity			
	15 min.	**30 min.**	**45 min.**	**60 min.**
Amblypharyngodon mola (mola)	21.66	30.24	36.74	45.24
Osteobrama cotio cotio (dhela)	30.45	38.76	42.33	48.25
Barbides sarana (puti)	30.25	40.22	45.66	50.33
Pseudotropius atherinoides (batashi)	40.35	50.55	55.84	62.04
Mystus vittatus (tengra)	45.25	51.74	58.02	60.25
Gudusia chapra (chapila)	30.00	45.00	50.66	53.77
Chela cachius (Phul chela)	25.33	35.22	42.56	45.79

Source: Nurullah et al. (2006)

It is interesting to see that the reconstitution behaviour of traditionally dried SIS products increased rapidly with the increasing socking time.

Table 9. Reconstitution behaviour of traditionally dried product at 80 ºC shown as percentage of water holding capacity

Samples	Reconstitution behavior of traditionally dried SIS in % water holding capacity			
	15 min.	**30 min.**	**45 min.**	**60 min.**
Amblypharyngodon mola (mola)	35.00	42.66	50.29	55.74
Osteobrama cotio cotio (dhela)	25.29	35.73	48.75	55.33
Barbides sarana (puti)	38.66	45.69	55.33	60.26
Pseudotropius atherinoides (batashi)	35.00	40.75	52.66	58.24
Mystus vittatus (tengra)	25.75	35.36	48.24	54.26
Gudusia chapra (chapila)	40.00	48.15	55.26	58.16
Chela cachius (Phul chela)	25.00	32.66	40.26	50.75

Source: Nurullah et al. (2006)

The rehydration of the products increased slowly with the increase of soaking time where maximum reconstitution was attained at after 60 min. with maximum value of 62.04 for batashi and minimum of 45.24% for mola. As shown in the Table 9, the phenomena of reconstitution behavior at 80 $^{\circ}$C for traditionally dried products were more or less similar to those obtained at 40 and 60 $^{\circ}$C except that the rehydration percentage at 80 $^{\circ}$C was considerably high and was in the range of 25.00 to 40.00% with maximum for chapila and minimum for chela after 15 min. of socking. The percentage of reconstitution increases with the increasing of socking time and at the end of 60 min. the values were in the range of 50.75 to 60.26% with maximum value in puti and minimum in phul chela.

A close relationship was found between the reconstitution power and physical properties of the samples. The quality of dried fish is also related to final a_w. At low a_w values, water uptake proceeds more quickly. In properly dried fish the water uptake is reported to complete in 3-15 minutes (Sikorski et al., 1995). If it is more than 15 minutes the quality of fish is considered to be questionable, Protein denaturation might be the cause of a decreased ability of rehydration. The poor rehydration in traditionally dried products was probably clue to the irreversible changes (denaturation) that took place during drying causing severe damage to the cellular structure. In such situation, the real reconstitution was impossible. The best way of reconstitution is to conserve a porous structure by a suitable method, which absorbs and retains sufficient water by capillary. Compressed products absorb slowly and less completely (Jason, 1965). The fibers of these sample muscles appeared to be cemented together and suffered hardly any of the separation induced by shrinkage. The samples of solar dried products exhibited an enormously rapid initial rate of rehydration, which was no doubt due to water being carried deep into the pieces by a porous structure which absorbed and retained sufficient water by capillary (Jason, 1965). The results obtained with traditionally dried products are in agreement with that which reported that with tough rubbery tissue water penetrated mostly to the center of large pieces by diffusion through the protein of fiber itself and the process was very slow (Connell 1957, Sen et al., 1961, Lahiry et al., 1961).

TVB-N, PO value and APC of traditionally dried products

The results of the total volatile base nitrogen (TVB-N), peroxide value (PO) and aerobic plate counts (APC) of traditionally dried products are given in Table 10. In traditionally dried fish the

TVB-N contents ranged from 32.50 to 45.45mg/100g with highest value in chapila and lowest value in mola.

Table 10. Total volatile base nitrogen (TVB-N), peroxide value (PO) and aerobic plate count (APC) of traditionally dried (TD) SIS products

Samples	**TVB-N (mg/100g)**	**PO (meq/kg oil)**	**APC (CFU/g)**
Amblypharyngodon mola (mola)	32.50	34.00	1.45×10^5
Osteobrama cotio cotio (dhela)	34.20	30.00	2.40×10^5
Barbides sarana (puti)	34.45	36.00	2.52×10^6
Pseudotropius atherinoides (batashi)	32.80	32.60	2.44×10^5
Mystus vittatus (tengra)	41.10	35.45	1.45×10^6
Gudusia chapra (chapila)	45.45	31.00	1.80×10^5

Source: Nurullah et al. (2006)

TVB-N values were much lower than the recommended value (100-200mg/100g) for variety of salted and dried fish products (Connell 1995). Volatile bases (ammonia, mono-di, and tri-methylamines) are of minor significance in the muscles of living fish but most important to fish handling, as they are found in the common pattern of spoilage. Volatile bases other than TMA are formed during spoilage.

Sen et al. (1961) reported that TVB-N value of sun-dried product varied from 32.5 to 41.0 mg/100g. Available reports suggest that in the case of fresh finfish such as cod) haddock, eel and sea pike, the upper limit of 30 mg TVB-N/100g is considered for acceptability (Kawabata, 1953). The TVB-N value is a useful parameter to assess the degree of freshness for chilled and frozen products but not suitable for the dried products because most of the volatile bases escape from the body during the drying process.

As shown in the Table 10 the PO values of the traditionally dried products were in the range of 30.00 to 36.00 m.eq./kg oil with maximum in puti and minimum in dhela. These values were, however, exceeds the range of suggested value of 10-20 (Connell, 1957).

The bacterial loads of traditionally dried samples of mola, dhela, tengra, katchki, puti, and chapila are presented in Table 10. The bacterial loads of traditional dried products ranged from 1.45×10^5 to 2.52×10^6 CFU/g with maximum value obtained from puti and minimum in mola. No Coliform bacteria or Salmonella was found in traditional dried products. The quality of dried fish is related to the final a_w. Most bacteria do not grow and multiply at a_w values below 0.95. Most of the traditionally sun dried product samples collected from local retail market was stored for 6-7 months in abusive condition. Enough moisture was absorbed from the air especially during the rainy season. Thus a suitable environment was created and total bacterial content exceeded the limit of acceptability.

Evaluation of quality aspects of dried marine fish products

Organoleptic characteristics

Sensory methods were used to assess the degree of freshness based on organoleptic characteristics of Silver jew fish, Bombay duck, Big-eye tuna, Chinese pomfret, Ribbon fish. The organoleptic characteristics of dried fish were determined to resolve the suitable drying temperature (Table 11). The quality of the dried fish products was assessed on the basis of color, odor, texture, insect infestation, presence of broken pieces and overall quality. The color of dried silver jew fish, Bombay duck, big-eye tuna and ribbon fish were from whitish to light brown color, whereas the Chinese pomfret was light-intense orange, which exhibit excellent color for the dried fish products. Texture was firm and flexible and odor was very much natural in all samples. No insect infestation or broken pieces were found around the products. The overall quality of the products was of excellent to good quality for all five marine fish species. It was observed that the flavor and color are important factors influencing the overall consumer acceptance.

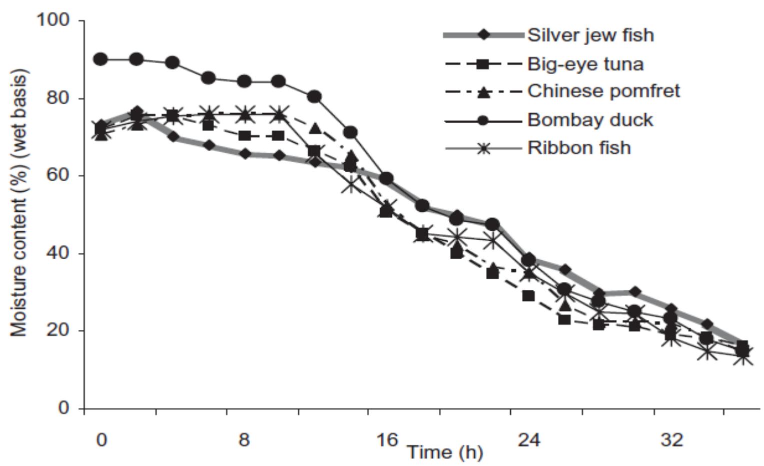
Table 11. Organoleptic characteristics of the dried marine fish products

Fish species	Organoleptic characteristics of sun dried fish	Overall quality
Silver jew fish	Characteristic odor; reddish color; firm and elastic flesh; no infestation; no broken pieces	Acceptable
Bombay duck	Characteristic odor; whitish color; firm and elastic flesh; no infestation; no broken pieces	Average
Big-eye tuna	Characteristic odor; reddish color; firm and elastic flesh; no infestation; no broken pieces	Acceptable
Chinese pomfret	Characteristic odor; shining light-intense orange color; firm and elastic flesh; no infestation; no broken pieces	Good
Ribbon fish	Characteristic odor; silvery color; firm and elastic flesh; no infestation; no broken pieces	Acceptable

Source: Reza et al. (2009)

Optimization of moisture content

Moisture transfer between the hot dry air and the fish samples may be represented by curves describing drying rate as a function of moisture content, relative humidity and a more or less constant air velocity. As shown in Figure 3, for silver jew fish, moisture content started to decline gradually with the increase of drying period. The moisture content of the sample reached at about 16% after 36 h similar studies were also conducted in other fishes as shown in Fig. 3. The trend of declining moisture content is more or less similar to that of silver jew fish but the drying period for reaching 16% moisture level in the final. It was interesting to see that except for Bombay duck, an initial increment of 2 to 4% moisture content was observed at around 4 h of drying period. Jason (1958) reported similar incident for drying of fish. As for Bombay duck, the moisture content remained more or less similar after 4 h of drying, which may be related to the high moisture content of the fish, a characteristic feature of the species itself (Reza et al., 2007). The changing pattern of moisture content of big-eye tuna, Chinese pomfret and ribbon fish during drying process is more or less similar to that obtained in silver jew fish. However, in big-eye tuna, moisture content reached to 16% or less in 36 h. For Bombay duck, Chinese pomfret and ribbon fish, it took 36 h.

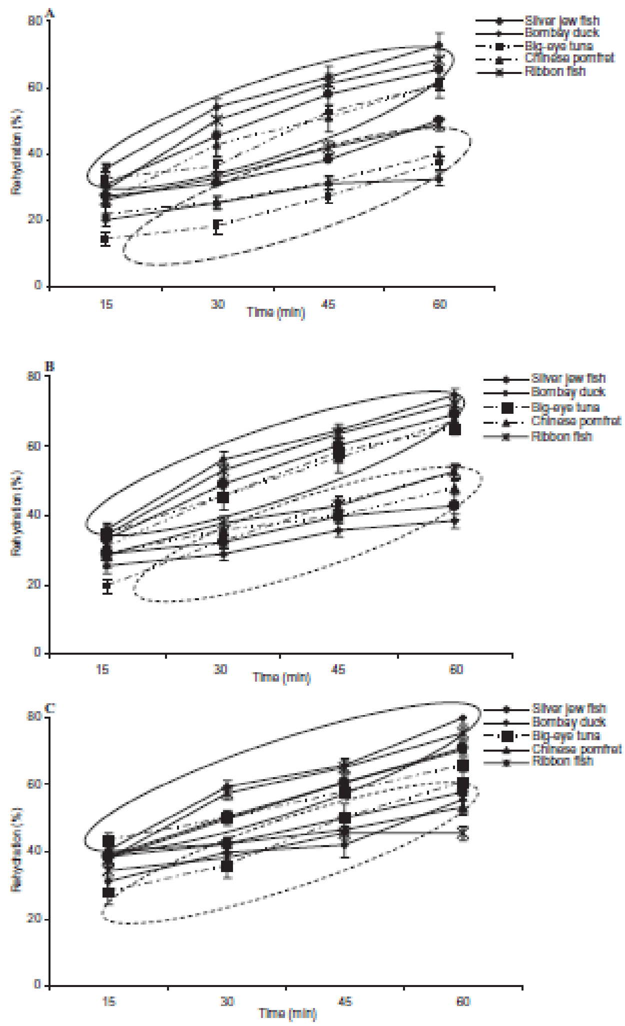


Source: Reza et al. (2009)

Figure 3. Optimization of moisture content of Silver jew fish, Big-eye tuna, Chinese pomfret, Bombay duck and Ribbon fish.

Rehydration ability/water reconstitution properties of dried marine fishes

The dried muscles obtained from dried products were soaked at 40, 60 and 80 ºC for 15 to 60 min. The results obtained from the study are represented in Figure 4 and it showed that rehydration ability in all fish samples were higher when soaked in elevated temperature and longer duration of soaking time. The value was in the range of 65 to 80% while soaking at 80 ºC for 60 min, lowest in big-eye tuna and highest in silver jew fish. Rehydration ability of the dried product was also studied for all fish samples and represented in Figure 4. The highest value of 60% was obtained in big-eye tuna and lowest value of 45% in ribbon fish.



Source: Reza et al. (2009)

Figure 4. Rehydration ability/water reconstitution properties of Silver jew fish, Big-eye tuna, Chinese pomfret, Bombay duck and Ribbon fish at (A) 40 ºC, (B) 60 ºC and (C) 80 ºC temperature.

Organoleptically, these products were also found very hard and elastic and very difficult for chewing even after cooking. A close relationship was observed between the rehydration ability and physical properties of the samples. Rehydration power was found to be slow with the poor texture such as tough, rubbery and compact structures with few interfibrillar spaces. This was especially true for ribbon fish and big-eye tuna. Compressed products absorb slowly and less completely (Jason, 1965). The very large differences in rehydration rates that existed between different products can be explained by their microstructural differences. The dried fish samples of silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish exhibited a rapid rate of rehydration, which was no doubt because of the water being carried deep into the piece by a porous structure that absorbed and retained sufficient water by capillary (Jason, 1965).

TVB-N and PV of dried Fish

The TVB-N and PV of dried silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish were determined in order to check the biochemical aspects of the products, and the obtained data are shown in Table 12. In all the dried fish samples, TVB-N values were found to be within the range of 1.9 to 25.2 mgN/100 g. Although the TVB-N value is not a useful parameter to assess the degree of freshness of the dried products (most of the volatile bases escape from the body during the drying process), the values of all samples were within the range of acceptable limit as described by Connell (1995). As for PV, they range from 3.9 to 18.8 meq/kg oil and they were also within the acceptable limit as suggested by Connell (1957).

Table 12. TVB-N, PV and APC values of some marine dried fishery products

Samples	**TVB-N (mg/100g)**	**PO (meq/kg lipid)**	**APC (CFU/g)**
Silver jew fish	3.5 to 25.2	4.5 to 14.3	1.8×10^3 to 2.6×10^4
Bombay duck	1.9 to 8.9	5.3 to 11.4	2.6×10^3 to 2.6×10^4
Big-eye tuna	2.5 to 15.2	12.1 to 13.50	5.4×10^4 to 6.0×10^5
Chinese pomfret	3.6 to 15.6	9.3 to 18.8	8×10^2 to 3.0×10^5
Ribbon fish	5.3 to 19.0	3.9 to 13.85	5×10^3 to 1×10^5

Source: Reza et al. (2009)

APC of some dried marine fish products

The APC values of some marine dried fish samples were also determined (Table 12) to check the bacteriological aspect of the dried products. The values ranged from 8×10^2 to 6.0×10^5 CFU/g, which fall within the acceptable limit for dried fish products.

Fish food safety aspects of three sun dried marine fish products

Sensory/Organoleptic characteristics

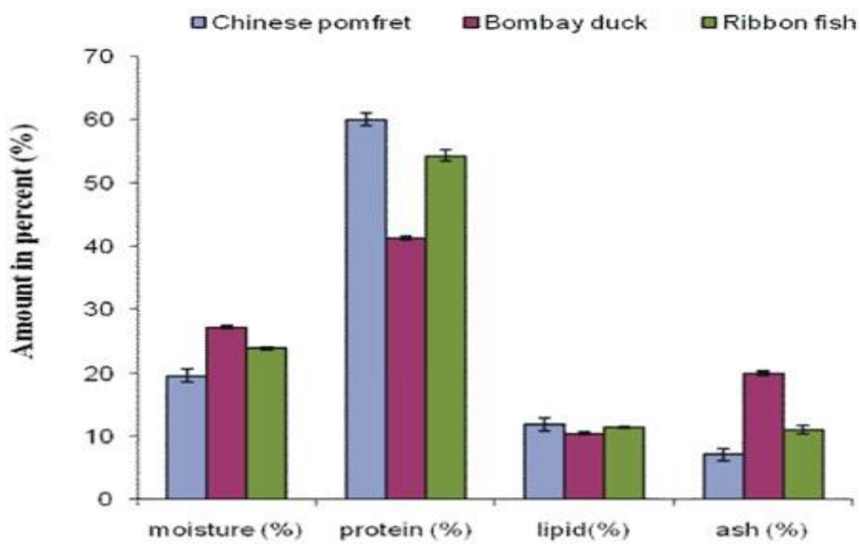
Results of the observations of physical and organoleptic characteristics of dried marine fishes are presented in Table 13. The quality of the dried marine fish products was assessed on the basis of color, odor, texture, insect infestation, presence of broken pieces and overall quality. The color of dried Chinese pomfret, Bombay duck and ribbon fish were from slightly silver to whitish color, which exhibit excellent color for the dried fish products. Texture was firm and flexible and odor was very much natural in all samples. Some insect infestation and no broken pieces were found in the products. It was observed that the flavor and color are important factors influencing the overall consumer acceptance, so the overall quality of these samples was of acceptable limit.

Table 13. Organoleptic characteristics of dried marine fishes

Fish species	Color	Odor	Texture	Infestation	Broken pieces	Overall quality
Chinese pomfret	Slightly silver	Characteristic odor	Firm and elastic	Some infestation	No broken Pieces	Acceptable
Bombay duck	Whitish color	Characteristic odor	Firm and elastic	Some infestation	Some broken Pieces	Acceptable
Ribbon fish	Slightly silver	Characteristic odor	Firm and elastic	Some infestation	No broken pieces	Acceptable

Source: Pravakar et al. (2013)

The result of proximate analysis (moisture, protein, lipid and ash) in wet weight basis and TVB-N content of dried Chinese pomfret, Bombay duck and Ribbon fishes are shown in Figure 5 and 6. Moisture content of Chinese pomfret and Ribbon fishes were 19.65±0.60 % (Where highest and lowest value varies from 18.98 to 20.13 %) and 23.94±0.2% (Where highest and lowest value varies from 23.73 to 24.21%) whereas the moisture content of Bombay duck was 27.19±0.27% (Where highest and lowest value varies from 26.89 to 27.40 %). Siddique et al. (2011) showed that the moisture level in the analyzed dried samples were varied from 22.22-34.99%, 20.76-32.65% and 13.81-20.50% respectively in three marine dry fishes (*Harpodon nehereus, Johnius dussumieri* and *Lepturacanthus savala*) during changes of storage period. For 2 years storing period, the moisture contents were increased by 12.77%, 11.89% and 6.69% for fishes. The findings of this study shows that the average moisture level obtained from our dry fishes are very close with the previous reports. Bhuiyan (1992) observed 6.9-14.2% moisture in dried marine fishes. It shows dissimilarities from present study because the dry fish traders keep the dry fish in wet and unhygienic condition and do not control the moisture and air temperature of the warehouse.



Source: Pravakar et al. (2013)

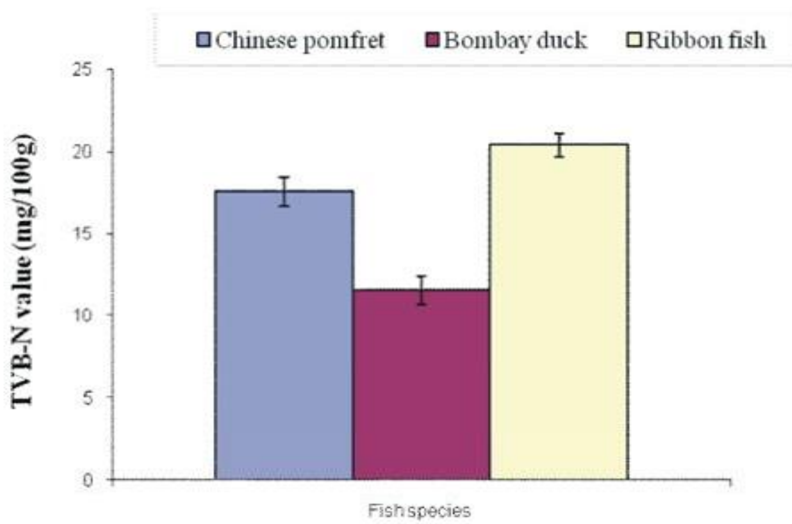
Figure 5. Proximate composition of dried marine fish products.

The protein content of Chinese pomfret 59.14 to 59.92 % and Ribbon fishes 53.42 to 55.08 % whereas the protein content of Bombay duck was 40.92 to 41.61%. The lowest mean value obtained from dried Bombay duck (41.28±0.35%) and the highest value from dried Chinese pomfret (60.03±0.94%) and 54.36±0.85% in Ribbon fish. Siddique et al. (2011) observed that the protein level of three marine dried fishes (*Harpodon 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. Bhuiyan (1992) observed 55.8-75.9% protein in dried fish sample (*Harpodon nehereus* and *Johnius dussumieri* respectively). A number of studies have been conducted on freshly stored dry fishes but these studies did not focus on the proximate compositions of longer time stored dried fishes. However, the findings of this study showed that the average protein level obtained from dried fishes were very close with the previous studies.

The lipid content of Chinese pomfret was (11.60 to 12.25 %) and Ribbon fishes ranged from 11.33 to 11.63% whereas the Bombay duck was 10.48±0.22%. Siddique et al. (2011) observed that the lipid level of three marine dried fishes (*Harpodon nehereus*, *Johnius dussumieri* and *Lepturacanthus savala*) was varied from 7.78-5.86%, 5.54-4.87% and 7.79-6.66%, respectively during changes 9.21-6.84% lipid in dried marine fishes. Both of findings were less similar to the present study.

The ash content of 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%. The lowest mean value was obtained from Chinese pomfret (7.21±0.18%) and the highest value from Bombay duck (20.06±0.36%) and also 11.05±0.69 % found from Ribbon fish. Siddique et al. (2011) observed that the ash level of three marine dried fishes (*Harpodon nehereus, Johnius dussumieri* and *Lepturacanthus savala*) was varied from 7.56-4.76%, 6.37-4.89% and 4.86-4.64% respectively during changes of storage period which were dissimilar to present findings. Gheyasuddin et al. (1980) found 9.98-4.56% ash in dried fishes which is in close quarters with the present investigation. Therefore, it is concluded that proximate composition of the fish is variable and dependent upon the species, size, sex and age of the fish, its geographical distribution and the season of the year.

The Total Volatile Base Nitrogen (TVB-N) content of Chinese pomfret, Bombay duck and Ribbon fish were 16.55 to 18.22, 10.55 to 12.20 and 19.56 to 20.89 mg/100g respectively in dry weight basis, where the lowest mean value obtained from Bombay duck 11.51±0.86 mg/100g and the highest value from dried Ribbon fish 20.37±0.71 mg/100g.



Source: Pravakar et al. (2013)

Figure 6. TVB-N content of dried marine fish products.

In Chinese pomfret mean value was 17.55±0.88 mg/100g. Reza et al. (2008) observed that the TVB-N content were 3.5 to 25.2, 1.9 to 8.9, 2.5 to 15.2, 3.6 to 15.6 & 5.3 to 19.0 mg/100 g for silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish respectively. Islam (2001) observed that Total Volatile Base Nitrogen (TVB-N) content of traditional dried ribbon fish, Bombay duck, big-eye tuna, silver Jew fish and Chinese pomfret ranged from 16.56-44.83 mg/100g. According to Connell (1995) the upper limit of TVB-N is 30 mg/100g for fin fish dried products acceptability. However, the findings of this study shows that's the TVB-N content obtained from dry fishes are very close with the previous studies and it is acceptable limit.

The total aerobic plate count expressed as colony forming unit in one gram of sample (CFU/g) of the representative samples of Chinese pomfret, Bombay duck and Ribbon fish were determined by standard plate count method on plate count agar media. Bacterial load of dried products were 3.8×10^5, 3×10^4 and 2.1×10^5 CFU/g respectively with lowest value in Bombay duck and highest value in Chinese pomfret (Table 14). Reza et al. (2008) observed that the aerobic plate count of dried marine fishes (silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish) 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 which is more or less similar to the values.

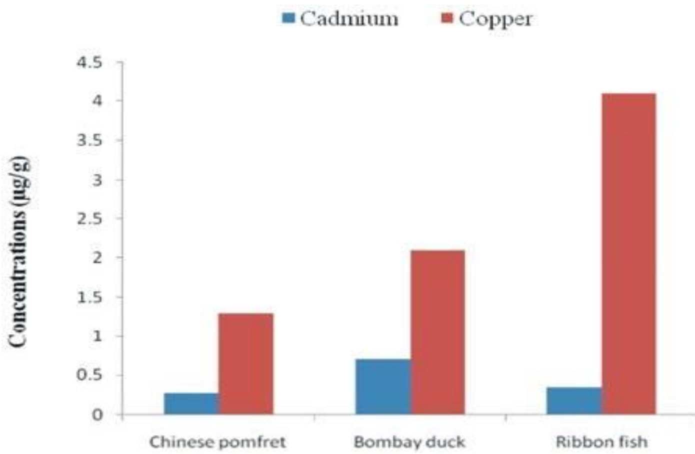
Table 14. Total aerobic plate count of dried marine fish products

Fish sample	**Aerobic Plate Count (CFU/g)**
Chinese pomfret	3.8×10^5
Bombay duck	3×10^4
Ribbon fish	2.1×10^5

Source: Pravakar et al. (2013)

The results of heavy metal concentrations in Chinese pomfret was Cadmium 0.28µg/g and Copper 1.3µg/g, in Bombay duck was Cadmium 0.71µg/g and Copper 2.1µg/g and in Ribbon fish was Cadmium 0.35µg/g and Copper 4.1µg/g respectively in dry weight (Figure 7). Kumar et al. (2012) were determined the concentration of Cu and Cd as in muscle tissue of fish species collected from North East coast of India where range of Cu and Cd in fishes was 0.5-28.2 and 0.01-1.10 µg g^{-1} dry wt. respectively which support to the present findings. The concentration of heavy metals was species specific and significantly different. In the tropical region like Bangladesh, the finished sun-dried fish products are typical and its shape and structure make it almost impossible to pack well enough to prevent uptake of water and consequently some degree of spoilage is almost inevitable during storage.

Therefore, it may be postulated that dried fish products even with low moisture content stored under no protection against high humidity can be the vehicle for most of the important types of bacteria responsible for food spoilage.



Source: Pravakar et al. (2013)

Figure 7. Heavy metal concentration of dried marine fish.

It is pointless for the people engaged in artisanal fisheries to store the dried fish products in a moisture and oxygen proof package when the price of that packaging puts the elegantly wrapped products beyond the purchasing power of the consumer.

CHAPTER IV
CONCLUSIONS

In the present study, the quality and safety aspects of different freshwater and marine water dried fish products were evaluated by examining the physical and organoleptic properties, chemical composition, total volatile base-nitrogen (TVB-N) and total bacterial load of the samples. Though the result of the study showed some variations but almost all of them were within the range of acceptable limit. In most of the cases abnormalities and quality loss was found when the products were not properly dried or stored. So, we need to focus on those particular things to improve the quality of the dried fishery products of Bangladesh which ensures the safety aspect of the consumer.

CHAPTER V

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